VOL. XIV, NO. 4 APRIL, 1922

GENERAL LIBRARY
MAR 30 1922
MAR 30 1922
UNIV. OF MICH.

# THE SCIENTIFIC MONTHLY

*EDITED BY J. McKEEN CATTELL*

## CONTENTS

MENTAL AND PHYSICAL CORRESPONDENCE IN TWINS. Dr. Arnold Gesell ..... 305

DEHYDRATION AND THE PRESERVATION OF FOODS. Dr. Heber W. Youngken ..... 332

A PERPETUAL SUBMARINE WAR. R. E. Coker ..... 345

THE NEGRO ENUMERATION OF 1920. Le Verne Beales ..... 352

AERONAUTIC ACCIDENTS OF TWO YEARS COMPARED. Dr. Ford A. Carpenter ..... 361

WHY THE MOVIES MOVE. Donald A. Laird ..... 364

THE SUB-CONSCIOUS—WHAT IS IT? Professor A. T. Poffenberger ..... 379

DISEASE AND INJURY AMONG FOSSIL MEN AND THE BEGINNINGS OF SURGERY. Professor Roy L. Moodie ..... 391

THE PROGRESS OF SCIENCE:
Government Control of Radio-telephony; The Helium Airship; The School of Hygiene and Public Health of the Johns Hopkins University; Scientific Items ..... 395

**THE SCIENCE PRESS**

**PUBLICATION OFFICE: 11 LIBERTY ST., UTICA, N. Y.**

**EDITORIAL AND BUSINESS OFFICE: GARRISON, N. Y.**

**New York Office: The Grand Central Terminal**

**Single Number, 50 Cents.** **Yearly Subscription, $5.00**

COPYRIGHT 1921 BY THE SCIENCE PRESS

Entered as second-class matter February 8, 1921, at the Post Office at Utica, N. Y., under the Act of March 3, 1879.

# A MILLION DOLLAR BOOK

Just Off the Press
30 Compact Volumes

The Only Up-to-date Encyclopedia

## For A Hundred Million People

## The ENCYCLOPEDIA AMERICANA

Our Subscribers Include:

Yale
Harvard
Princeton
Vassar
McGill
Johns Hopkins
Michigan
Ohio State
Ohio Wesleyan
Vermont
Virginia
West Point
Annapolis
Penn
Chicago
Leland Stanford Jr
Catholic University of America
—and many other Educational Institutions

JUST as America leads the world in reconstruction, wealth, invention, manufacture, so The AMERICANA establishes a new leadership over all reference works.

The revolutions in thought and progress, brought about by the War, made all encyclopedias obsolete. A restatement of the World's knowledge thus became imperative. The AMERICANA gives a wide view of the world as it is today — not as it was ten years ago.

COPYRIGHTED —— 1920

ENCYCLOPEDIA AMERICANA CORPORATION

27 WILLIAM ST., NEW YORK  PEOPLE'S GAS BLDG., CHICAGO

Gentlemen:

Please send descriptive literature - AMERICANA

NAME _____

ADDRESS _____

_____

_____

The Boston Public Library says:

"This is the first edition of any one of the larger encyclopedias to be published since the close of the European War."

*from* NEWS NOTES OF THE BOSTON PUBLIC LIBRARY

*January 15th 1921*

# THE SCIENTIFIC MONTHLY

APRIL, 1922


## MENTAL AND PHYSICAL CORRESPONDENCE IN TWINS


By ARNOLD GESELL, Ph.D., M. D.

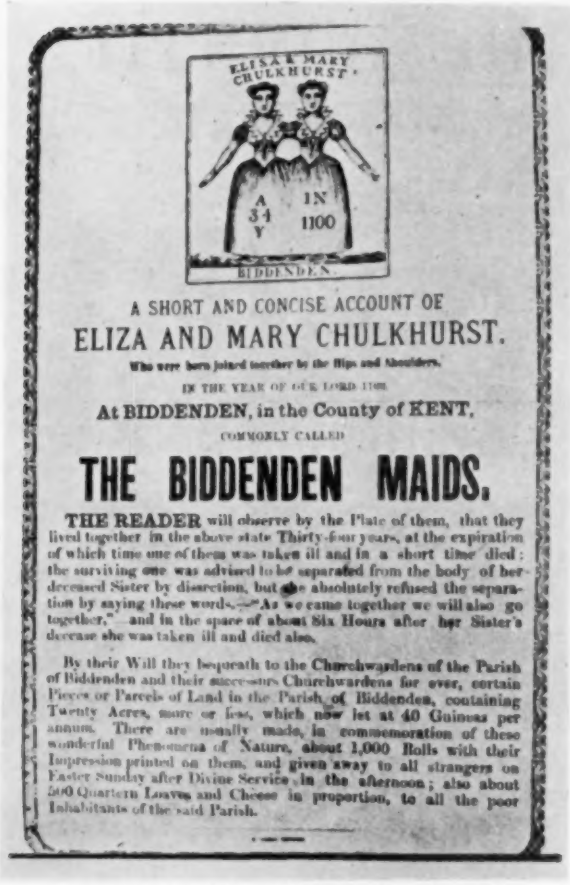
DIRECTOR OF YALE PSYCHO-CLINIC, NEW HAVEN, CONN.


### I. The Study of Twins

TWINS have always captured the curiosity and imagination of man. They figure in myths, traditions, superstitions, in art, in humor and in advertising. They are written in the constellations. Recently they have become one of the problems of science. Ancient Assyrians, Babylonians, Egyptians, Indians, as well as Hottentots used to kill both or one of a pair of twins, on the theory that twins were omens of ill luck or a form of sin. Though we hold no such erroneous conception, now-a-days, there is still a great deal of romancing about twins.

An antiquarian could compile a very interesting history of the subject. He could show how monsters and double monsters have left their impress upon legend and superstition. He could review for us the prescientific interpretations of such monsters and twins. Gould and Pyle in their *Anomalies & Curiosities of Medicine* have collected interesting facts revealing the extravagant and absurd character of these interpretations. Classical writings are sprinkled with truthful observations and conjectures; but modern embryology and teratology which have shed scientific light on the problems of twinning may be said to date back only to the eighteenth century.

The popular interest in twins, which is itself a suggestive psychological phenomenon, is by no means of recent date. For example, we have evidence to show that the Biddenden Maids who were born in Kent in 1100 A. D. excited quite the same curiosity which did the Siamese twins in the days of P. T. Barnum. The broadside reproduced from Ballantyne's *Antenatal Pathology* sums up the facts regarding this historical case (Figure 1). Whether these sisters were actually united by the arms may be questioned;


ELIZA & MARY CHULKHURST
A IN
34 1100
Y
BIDDENDEN
A SHORT AND CONCISE ACCOUNT OF
ELIZA AND MARY CHULKHURST.
Who were born joined together by the Hips and Shoulders.
IN THE YEAR OF OUR LORD 1100
At BIDDENDEN, in the County of KENT,
COMMONLY CALLED
THE BIDDENDEN MAIDS.
THE READER will observe by the Plate of them, that they lived together in the above state Thirty-four years, at the expiration of which time one of them was taken ill and in a short time died; the surviving one was advised to be separated from the body of her deceased Sister by dissection, but she absolutely refused the separation by saying these words,—"As we came together we will also go together," and in the space of about Six Hours after her Sister's decease she was taken ill and died also.
By their Will they bequeath to the Churchwardens of the Parish of Biddenden and their successors Churchwardens for ever, certain Pieces or Parcels of Land in the Parish of Biddenden, containing Twenty Acres, more or less, which now let at 40 Guineas per annum. There are usually made, in commemoration of these wonderful Phenomena of Nature, about 1,000 Rolls with their Impression printed on them, and given away to all strangers on Easter Sunday after Divine Service in the afternoon; also about 500 Quartern Loaves and Cheese in proportion, to all the poor Inhabitants of the said Parish.

*Reproduced from Ballantymes Antenatal Pathology and Hygiene.* Wm. Green & Sons, Edbg., 1904, p. 642.

FIGURE 1. "BROADSIDE" OF THE BIDDENDEN MAIDS

but there is no doubt that by their twin will they bequeathed twenty acres, the income from which the church wardens were instructed to spend in distributing cakes (bearing the impression of their conjoined image) to all strangers in Biddenden, at the close of divine service each Easter; and also "270 quartern loaves, with cheese in proportion, to all the poor in said parish."

About four centuries later, at about the time when America was discovered, we have another historical instance, the dicephalic twins, known as "the Scottish Brothers." They were described in quaint language by the Scottish historian, Lindesay, as follows:

> In this mean Time there was a great Marvel seen in Scotland. A Bairn was born reckoned to be a Man-Child; but, from the Waste up, was two fair Persons, with all Members and Portraitures pertaining to two Bodies, to wit,

Two Heads, well-eyed, well-eared, and well-handed. The two Bodies, the One's Back was fast to the Other's; but, from the Waste down, they were but one Personage, and could not know by the Ingyne of Man, from which of the two Bodies the Legs and Privy Members proceeded. Notwithstanding the King's Majesty caused take great Care and Diligence upon the Upbringing of their two Bodies in one Personage, caused nourish them, and learn them to sing and play upon Instruments of Musick; who, within short Time, became very ingenious and cunning in the Art of Musick; whereby they could sing and play two Parts; the one the Treble, and the other the Tenor; which was very dulce and melodious to hear. The common People who treated them also, wondered that they could speak diverse and sundry Languages: that is to say, Latin, French, Italian, Spanish, Dutch, Danish, English, and Irish. Their two Bodies long continued, to the age of twenty-eight years: and the one departed long before the other, which was dolorous and heavy to the other; for which many required of the other to be merry. He answered, How can I be merry, that have my true Marrow as a dead Carrion about my Back, which was wont to sing and play with me. When I was sad he would give me Comfort, and I would do the like to him; But now I have nothing but Dolour of the Bearing so heavy a Burden, dead, cold, and unsavory, on my Back, which taketh all earthly Pleasure from me in this present Life: Therefore I pray to Almighty God, to deliver me out of this present Life, that we may be laid and dissolved in the Earth, wherefrom we came.

The Hungarian sisters were born in 1701, and died almost simultaneously in their twenty-second year. They were conjoined twins, similar to the Biddenden sisters, and according to Gould and Pyle excited great curiosity. This curiosity was not limited to the populace. The twins were exhibited all over Europe, were examined by scientists, celebrated by poets (including Pope), described by Buffon in his Natural History, and memorialized in a Latin poem and in a bronze statuette. The sisters Millie-Christine (colored, born 1851); the Bohemian sisters (born 1878); the sisters Ritta-Christina (born in Sardinia, 1829); the Tocci brothers (born in Turin, 1877), all were conjoined twins and more or less famous in their day.

Most famous of all, however, were the Siamese twins (Figure 2), who were discovered in Siam and rescued by a British merchant, in 1824, when they were about thirteen years old. They were rescued in this sense. King Chowpahyi was planning to put them to death, because he thought they might bring evil to his country; but the merchant prevailed upon his majesty to allow them to go away for exhibition. They went directly from Siam to Boston, and later were shown the world over. Although of Chinese extraction, they adopted America as their home, settled down as farmers in North Carolina, under the name of Bunker, and married two sisters at the age of forty-four. They became Christians; and died in 1874.

From the time when they landed in Boston and were examined

*From Gould & Pyle Anomalies and Curiosities of Medicine.*
W. B. Saunders, Phdpha., 1897, p. 168.

FIGURE 2. THE SIAMESE TWINS AT THE AGE OF 18

by a Harvard professor, they became the object of both scientific and popular attention. A vast amount of literature has been written in regard to them. In 1830 a scientific memoir was read before the Royal Society of London, and is to be found in the Philosophical Transactions of that year. The memoir reports a lack of strong resemblance in Chang and Eng; striking correspondences in their pulse rates and in their tastes; reciprocity of symptoms under similar conditions of disorder; differences in dreams; and a remarkable degree of consent and mutual adjustment displayed in the physical movements of the twins. It is comforting to know that Chang and Eng could playfully tumble head over heels, without the slightest inconvenience. The author of this fascinating report, rather naïvely remarks that "they are at present very much attached to each other." As a matter of fact until their death they showed an affectionate forebearance for one another; and a highly developed sympathy, understanding and adaptation.

To bring this historical retrospect to date, it should be mentioned that there are at the present writing living in Washington a pair of "Siamese twins," natives of the Philippines, boys now in their teens. Under a ruling of the director of the census bureau they were counted as two persons in the last enumeration.

Twins have played a prominent part in modern medical literature, and the annual volumes of the "Index Medicus" and the Surgeon General's catalogue carry a considerable number of titles of articles on some phase of the subject. Significantly enough there is usually one group of references sub-classified under the head of *Twins, one blighted.* Taruffii in his monumental work on Teratology devotes 1,650 pages to the consideration of double monsters.

For biologists, twinning has become a problem of central importance. Bateson has defined twinning as the production of equivalent structures by division; and emphasized its fundamental nature. Important studies in symmetry, asymmetry, teratology, sex and heredity, have been made in this field. H. H. Newman, of the University of Chicago, has made extensive studies of twin production, habitually exhibited in the nine-banded armadillo of Texas; and has written a valuable volume on The Biology of Twins.[1] H. H. Wilder has reported in *The American Journal of Anatomy,* studies of physical resemblances in twins, shown by skin patterns of soles and palms. Galton has made a similar comparison of finger prints in 17 pairs of twins. Baldwin has made physical measurements of 3 pairs of fraternal twins and determined their differences in anatomical ages.

In 1918, The American Genetic Association announced its desire to communicate with twins living in any part of the world. Six hundred twins and parents of twins responded with letters and photographs; and in December, 1919, the Journal of Heredity devoted an entire number to discussion of the data on the general subject. This number contains an article by Dr. C. H. Danforth on Resemblance and Difference in Twins. Goddard devotes two pages to certain eugenic phases of the problem in his work on "Feeblemindedness: its Causes and Consequences."

The present writer, in 1921, published a study of 40 cases of hemi-hypertrophy, and discussed this condition in relation to mental defect and to twinning.[2] Hemi-hypertrophy is a unilateral enlargement of the body, which is interpreted as a developmental

[1] Newman H. H., *The Biology of Twins (Mammals)*, University of Chicago Press, 1917; pp. 186.

[2] Gesell, Arnold, Hemi-hypertrophy and mental defect. *Archives of Neurology and Psychiatry*, Vol. VI, pp. 400-423.

anomaly dating back to an early embryonic stage of cleavage,—a form of asymmetry due to a possible deviation in the normal process of twinning. The relatively frequent complication of mental defect is attributed to an abnormality in this process of bilateral twinning which involves a disturbance of normal tissue development.

The psychological aspects of the phenomenon of twins have not received their full share of attention. There are, however, two notable exceptions. The versatile Galton, who left few human problems untouched, made a suggestive, though rather leisurely, excursion into the subject in his *Inquiries into Human Faculty* in the year 1883. He used the questionnaire method and reported the returns of 80 cases of close similarity. Much of his material was anecdotal; but it was used to good advantage to prove the dominating influence of nature over nurture. He found only two cases of strong bodily resemblance being accompanied by mental diversity. He makes this characteristic suggestion: "It would be an interesting experiment for twins who were closely alike to try how far dogs could distinguish between them by scent!"

In 1904, Thorndike published an important monograph entitled "Measurements of Twins," based on precise measurements of 50 pairs of unselected public school twins from 9 to 15 years old, in 6 mental traits, and 8 physical traits. "The arguments concerned the lack of differences in the amount of resemblance (1) between young and old twins, (2) between traits little, and traits much subject to training and (3) between mental and physical traits, and also the great increase in resemblance of twins over ordinary siblings. The resemblance of twins was found to be approximately .80 or .75 to .80 in amount." The author considers that his data give well-nigh conclusive evidence that the mental likenesses found in the case of twins and the differences found in the case of non-fraternal pairs, when the individuals compared belonged to the same age, locality and educational systems, are due, to at least nine-tenths of their amount to original nature.[3]

"The form of distribution of twin resemblance seems to be that of a fact with a central tendency at about .80 and with a great variability, restricted towards the upper end by the physiological limit of complete identity. Such a distribution would be most easily explained by the genesis of twins as a rule from two ova and by a great reduction of the variability of contemporaneous germs and ova below that of germs and ova developed at different times." (p. 63.)

[3] Thorndike, Edward L. Measurements of Twins, *Archives of Philosophy, Psychology and Scientific Methods*, Vol. I, pp. 1-64.

Thorndike therefore refuses to classify twins into the two classical divisions, duplicate and fraternal. He does not find two coherent species of resemblance; and he doubts that there are but two corresponding modes of genesis (monozygotic and dizygotic). He believes that there is considerable specialization of resemblance in all type of twins. Although he finds that resemblance in general appearance and countenance is correlated by no means perfectly with resemblance in other traits, his figures show a tendency toward such resemblance. The medians of resemblance in (1) three head measurements, (2) in three stature and arm measurements, (3) in perception, (4) in association,—of twins of the same sex (a) closely alike and (b) not much alike in countenance are as follows: 1. (a) 85, (b) 70. 2. (a) 86, (b) 59. 3. (a) 84, (b) 63. 4. (a) 94, (b) 70.

## II. A Clinical Comparison of Duplicate Twins

We report herewith a case, or rather a pair of cases, which will serve as a basis for the consideration of the problem of resemblances in twins. We became interested in these two children, not because they were twins, but because of the exceptional superiority of their intelligence; and they were first studied from this point of view. Accumulating evidence, however, gradually convinced us that, regardless of their caliber, they presented a remarkable degree of correspondence in physical and mental constitution. It is this correspondence which is here emphasized. The facts have psychological interest, and may not be without some biological significance.

The twins will be referred to with an impersonal A and B, because there is no intention to publicly extoll them. We are not concerned to reveal their identity—except in the sense indicated by the term "identical twins!"

### (a) Developmental History

A complete family chart of the twin sisters A and B would show evidence of superior endowment in the immediate ancestry on both the maternal and paternal sides. Scientific and linguistic ability of high order and physical energy are some of the traits which are found in the two immediate generations. The trait of twinning likewise has a hereditary basis in this instance; for the mother also bore two boys, twins who died in infancy.

Their sisters A and B were born six years later, by Caesarian section, somewhat prematurely, weighing respectively 4.3 and 5.3 pounds. They thus escaped some of the hazard and strains which may accompany birth.

Their prematurity did not hinder precocity. At any rate,

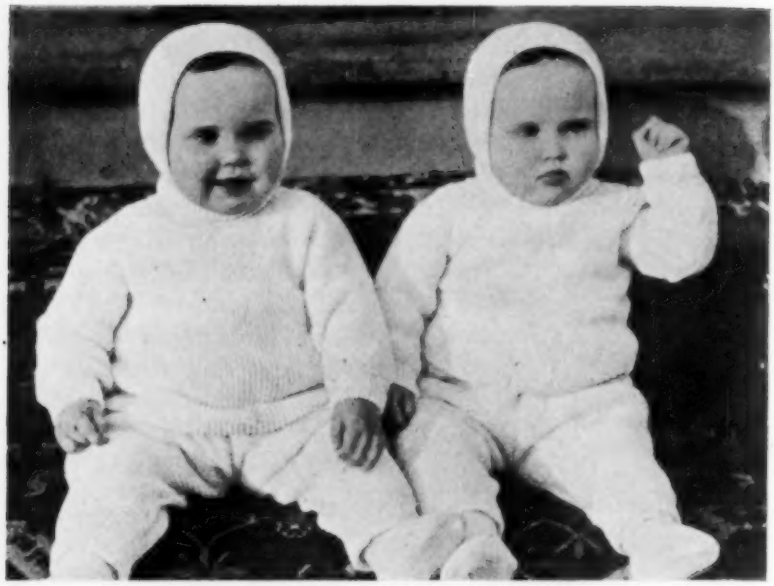


FIGURE 3. TWINS A AND B IN BABYHOOD

they very early showed unmistakable signs of more than ordinary alertness and attainment. At six months A startled her mother by rising suddenly into a sitting position in the mother's lap. Very soon after this B showed the same capacity. (Figure 3.) At 11 months they had both begun to walk and talk; indeed they were talking sentences, such as, "I see you, Auntie, * * *." They spoke clearly with less than the usual infantile lisping; and, according to report, with more than the usual degree of purposive, voluntary speech imitation. In October, 1915, at the age of three they began the study of French, and in less than a year (by April, 1916) they were reading elementary English, French and Esperanto. Their mother was a very constant companion; and stimulated this development by the aid of plays and games, but the children needed no prodding. They were distinguishing parts of speech with the aid of a Teddy Bear at the age of four; and at the same age one of them asked a searching question in regard to the Immaculate Conception. Formal arithmetic was begun at the age of six, and in less than a year they were solving mentally problems in fractions and percentage. They entered Grade III at the same age, and now at the age of nine, they are in Grade VII, doing Junior High School work. They are not prigs: they are attractive, animated, sociable children, with a bubbling sense of humor. They are popular with their playmates. They can take charge of a gymnasium class in which most of the members are two to four

years their seniors, and preserve excellent attention and discipline. They speak mature but not pedantic English, and they speak French with the fluency of a native. They have read Genesis in Italian and are now speaking a little Italian. They have read the Book of Knowledge in its entirety in French; and a year ago embarked on Russian. They play duets on the piano; but not with rare distinction. They swim; they ride horseback; they write jingles, and they read by the hour. Their school work does not tax them; they do not worry about it; and they are far from fastidious in regard to the form of their written work.

In this brief general review of their developmental history it is impossible to make any noteworthy distinctions between A and B. They have been inseparable, and abreast. Physically as well as mentally there has been a correspondence. They have both escaped most of the children's diseases; and neither has suffered a physical setback. So that now, as when they were babies, they are practically interchangeable children. The general impression made by physique, countenance, demeanor, conversation is one of complete similarity. A rather thoroughgoing analysis does not seriously disturb this impression of underlying identity of psychophysical make up.

### (b). Physical Tests and Measurements

Some twenty-five physical tests and measurements were made to determine the degree of physical correspondence between A and B. The results of this portion of the study are summarized in the accompanying table. An inspection of this table will show that in many items the correspondence amounts to complete identity and that in others it amounts to practical identity. Nowhere was a pronounced deviation revealed. The difference in standing height is one fourth inch in favor of A. The sitting height shows the same difference. Corresponding to this there is a difference of only one pound in weight. This disparity, however, is a variable one and sometimes B is slightly ahead of A in weight. The head girth shows a difference of but one eighth of an inch and the cephalic index which represents the relation between width and length of head shows a difference of only 0.7. The cephalic width is only 0.2 mm. greater in the case of B and the cephalic length 0.1 greater in B.

A very interesting and tangible criterion of anatomical development consists in the degree of ossification of the carpal bones. It is possible to ascertain this degree of ossification by a precise measurement of the exposed bone area as revealed by the X-ray (Figure 4). Such measurement can be made by means of the planimeter.

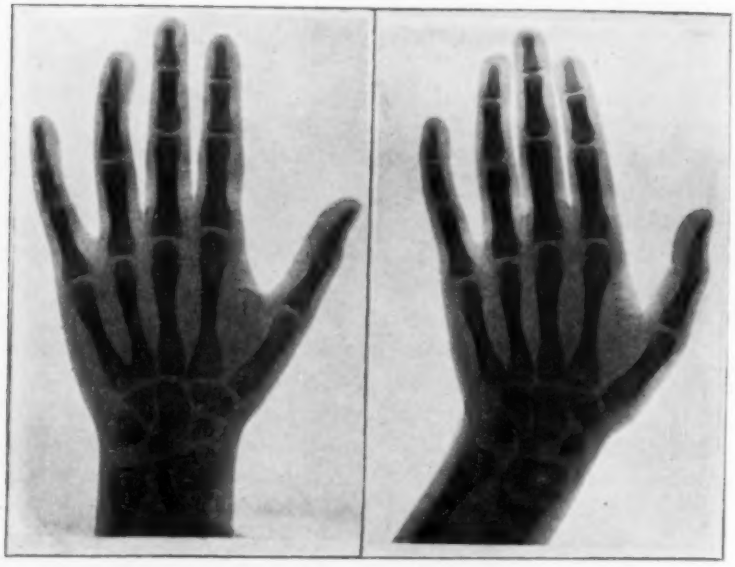


FIGURE 4. X-RAY PHOTOGRAPHS OF LEFT HANDS OF A AND B
Showing close correspondence in ossification of carpal bones.

Since, however, we were purely interested in making a comparison between A and B, our measurements were made by ascertaining the two major right angle diameters by means of a mm. rule. An examination of the table will show that four of the seven bones measured exactly alike. In the three other instances there was a

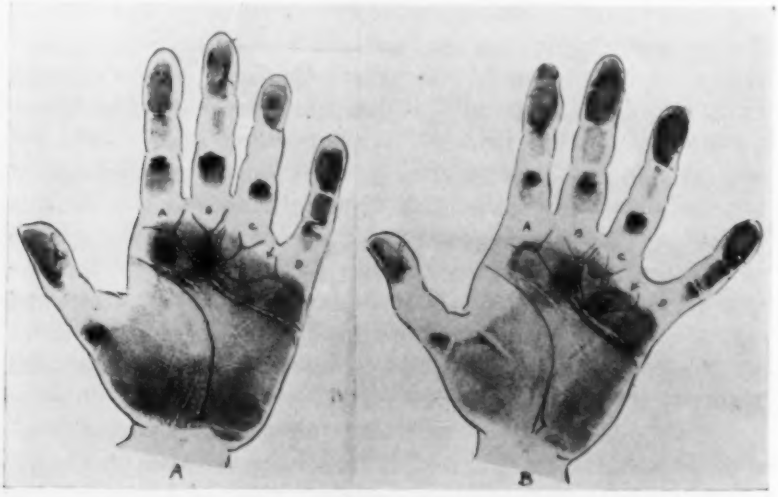



FIGURE 5. PALM PRINTS OF TWINS
Showing identity of skin patterns of right hands of A and B.
Formula, 9-9-5-5.C.

PHYSICAL TESTS AND MEASUREMENTS OF TWINS, A AND B, AGE 9

| Items Compared | A | B |
|---|---|---|
| Standing height | 48⅞ | 49⅝ |
| Sitting height | 25¾ | 25½ |
| Weight | 56½ | 55½ |
| Head girth | 20½ | 20⅝ |
| Head width (mm.) | 13.4 | 13.6 |
| Head length (mm.) | 16.5 | 16.6 |
| Cephalic index | 81.2 | 81.9 |
| Diameters of carpal bones: | | |
| Scaphoid | 5 x 10 | 5 x 10 |
| Semilunar | 7 x 10 | 8 x 11 |
| Cuneiform | 7 x 11 | 7 x 11 |
| Trapezium | 9 x 10 | 9 x 10 |
| Trapezoid | 7 x ca 7 | 7 x ca 7 |
| Os magnum | 11 x 20 | 12 x 20 |
| Uneiform | 8 x 15 | 9 x 15 |
| Total exposed area | 676 | 724 |
| Friction skin patterns: | | |
| Right palm | 9955C | 9955C |
| Left palm | 9955C | 9955C |
| Right sole | do. | do. |
| Left sole | do. | do. |
| Blood pressure: | | |
| Systolic | 95 | 96 |
| Diastolic | 65 | 70 |
| Pulse (resting) | 104 | 110 |
| Blood agglutination group | II | II |
| Vaccine pock | do. | do. |
| Dynamometer: | | |
| Right hand | 13 | 12 |
| Left hand | 12 | 11 |
| Spirometer | 78 | 80 |
| Tapping rate: | | |
| Right hand | 130 | 130 |
| Left hand | 127 | 118 |
| Steadiness | 14 | 17 |
| Dentition | do. | do. |
| Birth mole (upper lip) | do. | do. |

disparity of only one mm. in one or two diameters. Calculating the area on the basis of these diameters it appears that the total carpal bone area of A is 676 square mm. and of B 724. This is a very slight difference indeed and is no greater than that which is often found between the right and left hands of the same individual. According to Baldwin's figures, an average disparity of about 50 square mm. is to be expected between the left and right carpus. Baldwin has made a comparison of the carpal development in four pairs of fraternal (non duplicate twins) and the average amount of difference in bone area of these four pairs is 421

FIGURE 6. PLANTAR PRINTS OF TWINS
Showing identity of skin patterns of right feet of A and B.

sq. mm., a difference over ten times greater than that found in A and B, whom we regard as duplicate twins.

There is no more interesting means of making a physical comparison than that reported by the friction ridges of the skin. These friction ridges are found only on the surfaces of the palm and the sole. According to the comparative anatomist they date back to an arboreal ancestry, when certain animals in their active life among the boughs were much benefitted by the non-skid qualities of such ridges. The ridges were coarser in those days; but we still inherit them in indestructible patterns which appear in the fourth month of intra uterine life and are carried to the grave.

Sir Francis Galton said "Let no one despise the ridges on account of their smallness for they are in some respects the most

important of all anthropological data." Even in the ridge details there is absolutely no change in an individual from birth to old age. They furnish, therefore, a powerful aid not only for purposes of identification but for the comparison of individuals. A study of the palms and soles of A and B were made by Wilder's method. The right palms and right soles were mapped out to indicate the major subdivisions of the skin patterns. A remarkable degree of identity was shown in both the palmar and plantar patterns (Figures 5 and 6). The formula for the palm patterns is the same for both palms of both individuals, namely, 9.9.5.5.c. A minute analysis of certain areas of these patterns will show that the developmental correspondence has extended even to some of the minutiæ which are not regarded by Wilder as subject to detailed hereditary control. If the psychological correspondence of these two children approximates to any degree their anthropometric correspondence as indicated by the palm and sole diagrams, it is very great indeed.

A measurement of the blood pressure showed a difference of only one mm., systolic measurement and 5 mm. in the diastolic. Of these two measurements the systolic can be more accurately made and it is also the more important and the more readily ascertained. The correspondence is interesting. The resting pulse showed a difference of about six beats to the minute. A chemical diagnosis of the agglutination properties of the blood was made. In both cases the test showed the blood to belong to group II.

The development of bio-chemical tests for the measurement of individual differences is still in its infancy. The Benedict test for the determination of minute quantities of sugar in normal urine is supposed to reveal personal equations, but the conditions for accurate tests were too complex to carry out. An interesting similarity of a bio-chemical character was, however, exhibited in the reactions of the two girls to vaccination for smallpox. In both instances there was a very slight reaction without constitutional symptoms which occurred at the same time for both children. The dynamometer, spirometer, tapping and steadiness tests are included in the table because they have physical as well as psychophysical aspects. The differences revealed by these tests were very small indeed. The tapping rate for the right hands was identical.

Dentition is of course related to development. The first dentition could not be observed, but when the children were 8 years of age, the right upper permanent incisor was in both children in a similar incompleted stage of eruption. This is shown in the accompanying photograph (Figure 7) and presents a rather

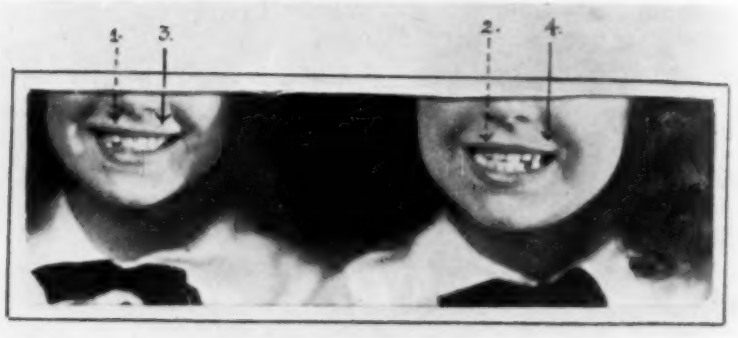



FIGURE 7. TWINS A AND B AT AGE 8
Showing correspondence in eruption of right upper incisor (1 and 2); and in location of tiny pigmented mole near left corner of mouth (3 and 4.)

startling indication of developmental correspondence. Finally may be mentioned one permanent indication of underlying identity of constitution. This is a tiny pigmented birth mole on the upper lip, situated a short distance from the left outer corner of the mouth in both twins. So here "the standard mole of the penny-novelists" could not even be relied upon for the purpose of personal identification, because both twins have the self-same mole! (Figure 7.)

There are several very tiny pigmented areas in the facial skin which are limited to one twin; and there are no doubt other physical deviations which minute study would disclose. Even two hairs, each but a half inch in length, taken from the same head, would as Wilder says, prove to be "absolutely unlike if magnified sufficiently to show the epidermic markings that cover the surface with a fine tracery." By such ultra refined standards, complete identity is a mathematical impossibility; but general, coherent correspondence and absolute identity are two quite different considerations. Our data compel us to recognize a basic developmental and physical correspondence in Twins A and B.

Since this correspondence has expressed itself in such structural details as teeth, skin patterns, birth moles, and cranial and carpal bones, it is not unreasonable to suppose that it should also assert itself in the general architecture and organization of the nervous system. We can gather some light on this point by inquiring into the mental correspondences, through the use of psychometric methods.

### (c) Mental and Educational Measurements

The adjoined table summarizes the results of a group of intelligence, performance, and educational measurements of A and B

which were made at the Yale Psycho-Clinic, and at the home of the children. The writer wishes to acknowledge the assistance of Dr. Margaret Cobb in the administration of these tests. The co-operativeness of the subjects who entered into all of the situations in the spirit of a game, enlivened with rivalry, aided us. The subjects deserve our especial thanks; for they were indispensable in this particular study.

| Mental and Educational Test | A Score* | B Score* | A Age Norm. | B Age Norm. | Remarks |
|---|---|---|---|---|---|
| 1. Binet, Age 7 | 188 | 181 | 13.5 | 13 | Average I. Q.: A, 183+ B, 183 |
| 2. Binet, Age 8 | 179 | 185 | 14.75 | 15.25 | |
| 3. Vocabulary, Age 7 | 50 | 50 | 14 | 14 | |
| 4. Vocabulary, Age 8 | 52 | 54 | 14+ | 14+ | |
| 5. Vocabulary, Age 9 | 67 | 65 | 16 | 16 | |
| 6. National Intelligence, Age 9 | 136 | 155 | 15 | 15+ | |
| 7. Porteus | | | 12.25 | 11.25 | A shows more foresight. |
| 8. Ship | 18 | 20 | 11 | 13 | |
| 9. Feature Profile | 150 s | 250 s | 15 | 10 | |
| 10. Diagonal | 195 s | 70 s | 6 | 10 | |
| 11. Triangle | 25 s | 30 s | 14+ | 14 | |
| 12. Knox Cube | 7 | 10 | 14— | 18 | |
| 13. Healy A | 205 s | 135 s | 9 | 10 | |
| 14. Seguin Form Board | 28 s | 30 s | 7+ | 7 | |
| 15. Healy Coordination | 305 | 445 | | | A more deliberate. |
| 16. Opposites | 40 s | 80 s | | | B spent 45 sec. on last word. |
| 17. Easy Directions | 98 s | 85 s | | | No errors; both showed intense interest and attention. |
| 18. Hard Directions | 175 s | 155 s | | | |
| 19. Symbol Digit | 23.4 | 12.2 | 12 | 9 | |
| 20. Trabue Language Completion | 13 | 13 | 13.5 | 13.5 | |
| 21. Kansas Silent Reading | 12.9 | 21.5 | 12.5 | 13.5 | |
| 22. Woody Fundamentals of Arithmetic | 28 | 26 | 12.5 | 12.5 | |
| 23. Ayres Spelling | VIII | VIII | 14.5 | 13.5 | |
| 24. Ayres Handwriting | 60 | 60 | 13 | 13 | Differentiation increasing. |
| 25. Drawing (Thorndike) | 10.5 | 10.5 | | | |
| Accuracy (15) | 90% | 80% | | | |
| Average for combined tests | | | 13.6 | 13.9 | |
| Average for performance tests | | | 11.75 | 12 | |
| Standard deviation | 2.83 | 2.91 | | | |

*S = second.

The mental examinations were not, of course, all made at one sitting; but the twins were always submitted to the selfsame tests on the same days.

The results of these tests for which we have standardized age norms are plotted on the accompanying chart (Figure 8), in which the solid line stands for A's performance and the broken line for B's. It is hardly necessary to give mathematical expression to these curves. The two lines show a striking degree of cohesion. Note, for example, how they both plunge down on the formboard test, and how equally they rise on the vocabulary tests. The most pronounced disagreement is that shown in the feature profile test. Here there was apparently a more or less fortuitous circumstance, which disturbed B's attack of the problem. Indeed it is quite likely that not a few of the minor disparities shown in the performance scores in various tests indicate variation in the conditions of the test, beyond our control, rather than fundamental differences in mentality. In view of this, the amount of psychological correspondence actually revealed by the tests is all the more significant.

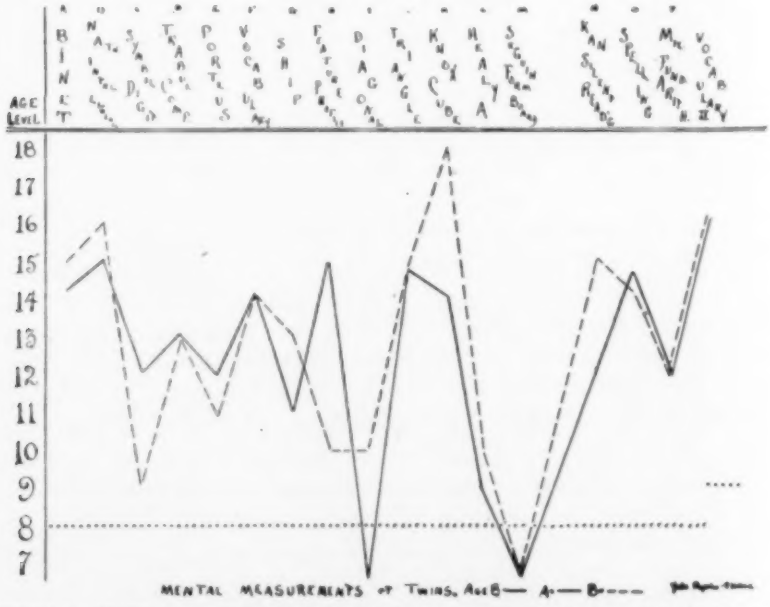



FIGURE 8. GRAPH SHOWING CORRESPONDENCE IN MENTAL MEASUREMENTS OF A AND B

The results are plotted on the basis of mental age scores, the heavy straight dotted line representing the chronological age. The tests in order are (*a*) *Binet*, (*b*) National Intelligence, (*c*) Symbol Digit, (*d*) Trabue Completion, (*e*) *Porteus*, (*f*) *Vocabulary*, (*g*) *Ship*, (*h*) *Feature Profile*, (*i*) Diagonal, (*j*) Triangle, (*k*) Knox Cube, (*l*) Healy A, (*m*) Seguin Form-board (*n*) Kansas Silent Reading, (*o*) Ayres Spelling, (*p*) Woody Mixed Fundamentals of Arithmetic, (*q*) Vocabulary II.

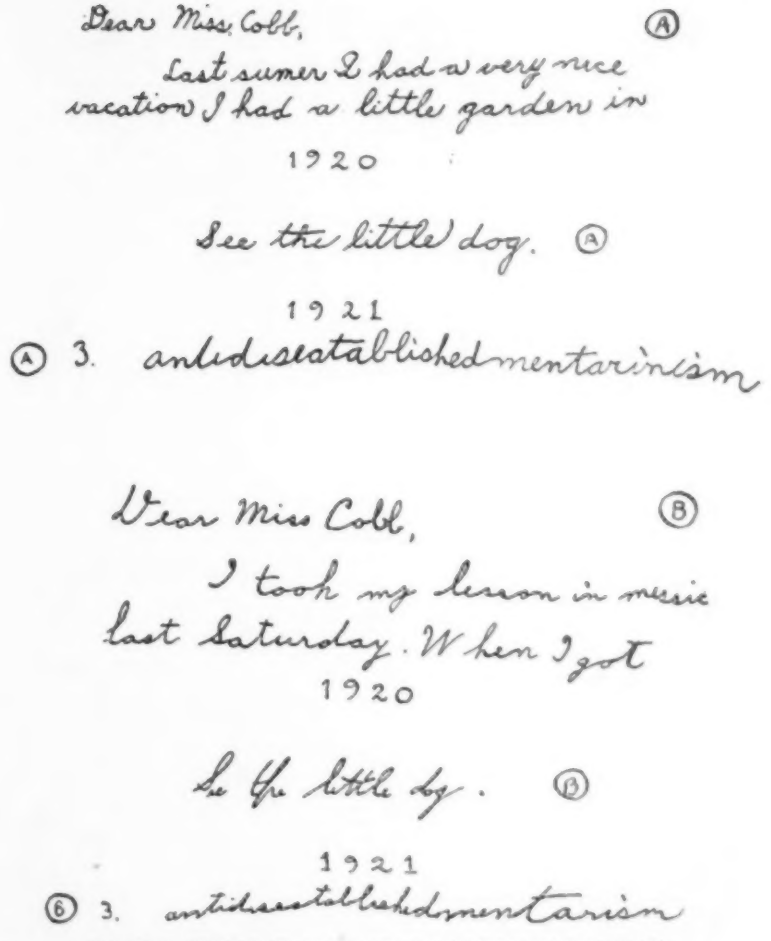
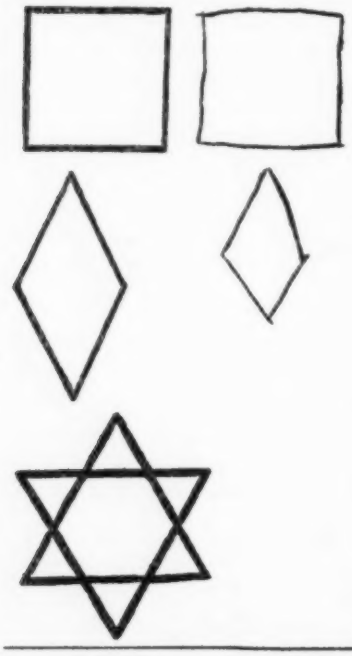


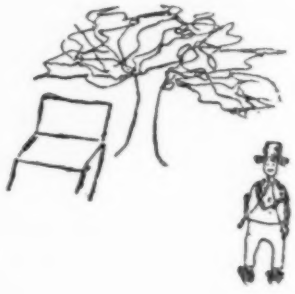

FIGURE 9. HANDWRITING OF A AND B (REDUCED TO TWO-THIRDS)
Showing a moderate degree of similarity in 1920 specimens, and an accentuation of points of difference a year later. The specimens marked 3 show the third trial at spelling the "word," *antidisestablishmentarianism*.

Qualitatively as well as quantitatively the tests revealed a consistent similarity with respect to general alertness, intensity of attention, deliberation, cooperativeness, sense of humor, and emotional reactions. Comparative ratings with regard to quality of responses were attempted in 25 of the Binet tests. In 12 of these our rating was equality, in 13 a slight superiority in favor of B who showed perhaps a little more directness, conciseness and power of generalization. But these ratings were subjective at best, and rested so near to the limit of imperceptible difference, that it would be pedantic to insist on their importance. For once let us insist on resemblance rather than differentiation.

18. Give the child a pencil (but no ruler) and say: You see that (pointing to the square). I want you to make one just like it. Make it right here (pointing to the space adjoining). Go ahead. Repeat this formula for each figure.



In the space below have the child draw a man and a tree with a bench under it. Give no further directions or assistance.



Draw Star Here

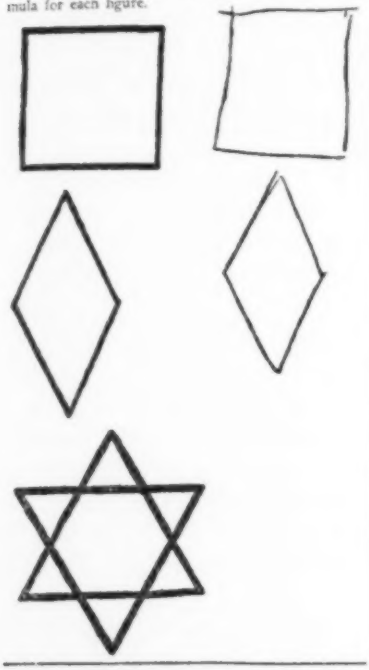
19. Point to the round field, and say to the child: *Let us suppose that your ball has been lost in this round field. You have no idea what part of the field it is in; but you know it is there somewhere. Now take this pencil and begin at the gate and mark out a path to show me how you would hunt for the ball so as to be sure not to miss it.*

FIGURE 10. DRAWING TESTS—TWIN A

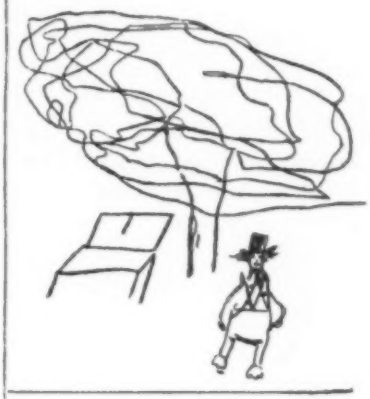
In addition to the purely psychological tests, several educational tests were given to measure achievement in reading, writing, arithmetic, spelling and drawing. The results showed close similarity in every instance, with the exception of silent reading, in which B made a somewhat superior score.

In spelling, the standard Ayres word list was used. By way of good measure, the girls were also given a chance to spell "the largest word in the language." They responded with their usual eagerness. I pronounced, three times, the formidable "word" *antidisestablishmentarianism*. They tried to spell it after each

18. Give the child a pencil (but no ruler) and say: You see that (pointing to the square). I want you to make one just like it. Make it right here (pointing to the space adjoining). Go ahead. Repeat this formula for each figure.



In the space below have the child draw a man and a tree with a bench under it. Give no further directions or assistance.



Draw Star Here

19. Point to the round field, and say to the child: *Let us suppose that your ball has been lost in this round field. You have no idea what part of the field it is in, but you know it is there somewhere. Now take this pencil and begin at the gate and mark out a path to show me how you would hunt for the ball so as to be sure not to miss it.*

FIGURE 11. DRAWING TESTS—TWIN B

pronunciation. The results of the third trial are shown in the illustration. Both inserted a superfluous *ed*, in the middle; A missed the rest of the word by one letter, and B by three. (Figure 9.)

The reactions of the twins in the field of drawing are pictured in the accompanying illustrations, (Figures 10 and 11). The twins were asked independently to copy a square, a diamond and a star; to trace the route in the ball and field test, and to draw (without copy) a man and a tree with a bench under it. These responses under controlled conditions furnish a basis for objective comparison. The general similarity is unmistakable, as

shown by the illustrations. The similarity of the free drawings of man, tree and bench is the most remarkable. It can, of course, be partly accounted for by the conventionalizing effect of reciprocal imitativeness, favored by the intimate companionship of these two children; but after all the fact that this conventionalizing process should produce such an assimilative result denotes an underlying similarity in mental constitution.

Handwriting is an expression of individuality. It is not necessary to go as far as the graphologists do and consider it an index of character; because it is of course subject to fortuitous, mechanical and purely technical influences. However, Wilder and Wentworth are probably correct in their statement that "more than any other single gesture or habitual pose, a man's natural handwriting is the product of what he has experienced, learned, and practiced repeatedly, mind and body cooperating in every stroke." Osborn interprets penmanship as the combined product of muscular habits and mental patterns which "differ in a marked manner in different individuals and this variation radically affects the visible result." On these constitutional variations rests the possibility of identifying individuals and detecting forgery through handwriting.

When it comes to a comparative study of twins, handwriting therefore suggests itself as a psycho-motor test. It must indeed be a delicate test, for complete similarity is apparently very rare. Galton, however, reports one case in which not even the twins themselves, though adults, could distinguish their own handwriting. In our own case of A and B, there was a moderate degree of similarity at the age of 8, as shown by the accompanying illustrations (Figure 9). The reader will note, however, a little more angularity, compression and reduction in size, in B's specimen. These differences in the course of a year have become accentuated, so that the general similarity of the earlier stage is disappearing. That the differentiation will grow still more marked with adolescence is not improbable. And who knows what other chirographic metamorphoses will attend this period, in which individualism in loops, hooks, flourishes, etc., frequently abound?

The vocabularies of A and B deserve particular discussion; because we may feel certain that these two girls have been subjected to a nearly identical language environment. They have been inseparable; they have talked and held their tongues to very nearly the same extent; they have had the same mother, the same mother tongue; they have had equal instruction in the same foreign languages; they have listened, usually at the same time to the

same relatives, friends and teachers; have studied the same lessons and have read much the same books. With what results?

It would be fallacious to say, that *because* A and B have been exposed to the same verbal environment, they will be familiar with the same words. Familiarity with words depends upon other factors than mere impression. It depends upon the capacity to assimilate meanings, concepts, contexts, inflections. It depends upon curiosity and attitudes, upon social propensities, tastes, preferences, and above all upon maturity.

Numerous psycho-metric determinations of the vocabulary of children have shown a consistent tendency for the vocabulary score to increase with age, and with intelligence. Vocabulary is so highly correlated with mental development, that even the son of an immigrant, who hears nothing but a foreign language at home, will after brief residence in this country earn a high vocabulary rating, if he is of superior endowment.

Our twins have since babyhood shown a sprightly facility in the realm of words. They have taken much delight in various forms of sound and word play, and have betrayed a lively and often humorous interest in words. Both of the children like to rhyme, and B is blossoming into poetical composition. The accompanying sample is not unpromising, when we consider that the chronological age of the "poetess" is nine!

THE BIRTH OF FLOWERS

When flowers first were born,
The earliest flow'r of Morn,
Was the Rose,
So Sweet and wondrous in its
pose.
The flowers all assembled
To chose their Queen,
The fairest one amongst
them I ween;
The rose spoke up
And said, "The one that
goes latest to
bed."

It was possible to make a satisfactory comparison of the twins A and B by means of a vocabulary test. This test, Terman considers to have a far higher value than any other single test in the whole intelligence measuring scale. The test consists of 100 words derived by random selection from a dictionary containing 18,000 words. An abbreviated series of 50 words of increasing difficulty ranging from *gown* and *tap* to *shagreen* and *complot* was given to both A and B. This virtually constituted a graded scale of 50

individual tests, and revealed a startling degree of resemblance; A failed on 16 of the test words; B failed on exactly the same words, and on only one additional word, namely *harpy*. The calculated vocabulary score of A at the age of 9 is 65 and for B it is 67, a standard equivalent to the average adult level.

VOCABULARY TEST

| | A. | B. | | A. | B. |
|---|---|---|---|---|---|
| 1. gown | + | + | 26. Mars | + | + |
| 2. tap | + | + | 27. mosaic | + | + |
| 3. scorch | + | + | 28. bewail | + | + |
| 4. puddle | + | + | 29. priceless | + | + |
| 5. envelope | + | + | 30. disproportionate | + | + |
| 6. rule | + | + | 31. tolerate | + | + |
| 7. health | + | + | 32. artless | — | — |
| 8. eye-lash | + | + | 33. depredation | — | — |
| 9. copper | + | + | 34. lotus | + | + |
| 10. curse | + | + | 35. frustrate | — | — |
| 11. pork | + | + | 36. harpy | + | — |
| 12. outward | + | + | 37. flaunt | — | — |
| 13. southern | + | + | 38. ochre | — | — |
| 14. lecture | + | + | 39. milksop | — | — |
| 15. dungeon | + | + | 40. incrustation | — | — |
| 16. skill | + | + | 41. retroactive | — | — |
| 17. ramble | + | + | 42. ambergris | — | — |
| 18. civil | + | + | 43. achromatic | — | — |
| 19. insure | + | + | 44. perfunctory | — | — |
| 20. nerve | + | + | 45. casuistry | — | — |
| 21. juggler | + | + | 46. piscatorial | — | — |
| 22. regard | + | + | 47. sudorific | — | — |
| 23. stave | + | + | 48. parterre | — | — |
| 24. brunette | + | + | 49. shagreen | — | — |
| 25. hysterics | + | + | 50. complot | ± | ± |

+, passed. —, failed.

This degree of correspondence is truly remarkable when we reflect that this searching test, in a statistical sense, compasses the whole wide domain of the English language. Although we must give due weight to the similarity of verbal and academic environment to which A and B have been subjected, do not the results of the test testify even more eloquently to an underlying similarity of nervous constitution and organization?

Incidentally we may record a characteristic reaction which occurred in the course of the first vocabulary test which I gave to the twins at the age of 7. A encountered a word which sounded familiar, but for which she could frame no definition. The word was *civil*,—"Civil, don't know; can't say; and yet I think I know. O, that reminds me: it is like that story about space. A teacher asked his pupil to define *space*. The boy said, 'I can't tell you what it is, but I've got it in my head.'" Thereafter, whenever

an unfamiliar word was presented, A smiled slyly, tapped her head and said, "I guess it's that space story again!" Even so, both girls at the age of seven had a vocabulary score of 50, equivalent to the mental age of 14. Moreover, they knew when they didn't know. Mentally inferior children venture wild definitions in the field of the unknown.

There are no satisfactory objective methods for directly measuring emotional and volitional traits. We, of course, secure data concerning them indirectly through so-called intelligence measurements; but we are chiefly dependent upon clinical inference and estimate. Even so, it would require a psychological Boswell to furnish a complete comparative picture of the temperaments and dispositions of A and B. Long continued and intimate observation might reveal some interesting disparities in the emotional sphere. The ordinary observer would probably develop a partiality for one of the twins on the ground that A or B is less assertive, more reasonable, more affectionate, than B or A. But this preference might indicate the inveterate selective and discriminative tendency of human perception, quite as much as a fundamental diversity in the twins.

Assuming that there is at present a high degree of correspondence in temperamental traits: does it follow that such will always be the case? Hardly so. To begin with these children have not as yet come into full possession of all of their mental inheritance. Adolescence brings with it many new psychic characters, and these may not be equally shared, or equally assimilated by A and B. And as we look down the future we must reckon with the differentiating power of differences in fortune, social position or professional career. We have noticed that one twin is definitely more dependent upon demonstration of affection by the mother; that one is becoming interested in the violin, the other, perhaps in poetry. Suppose that one should seek distinction in music and the other in letters. Even such a relatively small disparity in vocation might ultimately create by accretion a very decided difference in mental content, habits of thought, social attitudes, outlook upon life; so that the conditioned reflexes and complexes of A would become quite distinguishable from those of B; an interesting difference in vegetation, growing upon much the same soil. Personality in its higher expressions is always so conditioned by social and educational factors that it would be futile to deny the possibilities of differentiation even with "duplicate twins."

But we are concerned with the present status of twins A and B, age 8. At that age we gave them an opportunity to express some of their likes and dislikes on paper. It was a simple, almost

impromptu test; but the results were amazing. They independently answered in writing a questionnaire, which is reproduced with their replies exactly as they gave them.

QUESTIONS ON LIKES AND DISLIKES, ANSWERED IN WRITING INDEPENDENTLY BY A AND B

*Question:* If you had $1,000.00 to spend, how would you do it? Tell me about it on this page.

*Answer:* A. I would buy a painting outfit and learn to use it. Take Mother to Europe (because she wants so much to go).

B. I would buy a horse (like Black Beauty), a riding habit, the Universal Anthology for Mother and a barrel of sugar for my horse.

*Question:* What is the most unpleasant thing you have to do every day?

*Answer:* A. Practice on the piano.

B. Practise on the piano.

*Question:* What is the most agreeable thing you do every day?

*Answer:* A. Ride horse-back.

B. Ride horse-back.

*Question:* What is most likely to make you angry?

*Answer:* A. Our dog.

B. Rasputin. (The dog.)

*Question:* What is it your ambition to be when grown up?

*Answer:* A. An artist.

B. To teach.

*Question:* What game do you like best?

*Answer:* A. Play lady and dress up in Mother's clothes.

B. Mother.

*Question:* What was the most fun you had last summer?

*Answer:* A. Going in swimming.

B. Going in swimming.

*Question:* What is your favorite color?

*Answer:* A. Green.

B. Green.

*Question:* What Is your favorite book?

*Answer:* A. Bible stories.

B. The Bible.

*Question:* What is your favorite song?

*Answer:* A. Red, White and Blue.

B. Home Sweet Home.

*Question:* What is your favorite study in school?

*Answer:* A. Reading.

B. Reading.

It would be easy to exaggerate the significance of these questionnaire results, and yet it is inconceivable that they would have been possible without a considerable degree of correspondence in personality traits. The same conclusion must be drawn from the results of the vocabulary tests made at seven, eight, and nine years of age. The close correspondence in mental level revealed by the Binet ratings is also undeniable. There were several points of difference in the I Q at the ages of seven and eight, but the average for the two testings was within one point,—183.

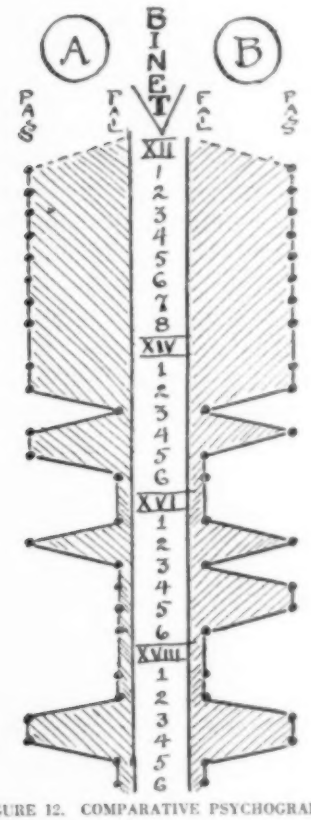



FIGURE 12. COMPARATIVE PSYCHOGRAPH

Showing intellectual correspondence of Twins A and B at age 8. Forty-four graded intelligence tests were given. All the tests at the mental age levels of 8 to 12 inclusive were passed with facility.

The I Q, or Intelligence Quotient, expresses the ratio of mental age to chronological age. If these two ages are the same in a given individual the I Q is 100. If the mental age is less than the chronological, the I Q is below 100. If the mental age is in advance the resulting I Q is above 100. Children with an I Q of 65 or less are usually feebleminded. Children with an I Q of 120 or more may be regarded as relatively superior. The psychological literature reports very few cases with an I Q as high as 180.

A comparative psychograph of the performances of A and B in the Binet tests gives a fair graphic picture of the degree of intellectual correspondence of these two children at the age of 8. The diagram (Figure 12) is so drawn that success and failure are indicated in corresponding meridians. All the tests in the age levels below 12, were passed with great facility and are not included.

One half of the psychograph proves to be almost a mirror image of the other.

### (d) General Conclusion

Reviewing, then, the developmental history of A and B, and the results of scores of tests,—the physical, the anthropometric, the psychological, performance and educational measurements; and considering the collective weight and tendency of these findings, and the wider diversity which would have been shown by a similar study of ordinary siblings—it seems highly probable that this pair of twins were of nearly duplicated or identical genetic antecedents.

The general conclusion is inescapable that the consistent similarity between these two children is based upon a fundamental, inherent similarity in endowment. It would, however, be wrong to ignore the equalizing influence of a practically identical environment. Indeed, in studying the development of personality it is rather artificial to bring nature and nurture into rigid contradistinction. Personality represents the resultant cooperative product of both intrinsic and extraneous factors, and the interaction of these factors in highly dynamic relations. It is because these dynamic relations are so sensitive, that any marked psychological similarity even between co-twins at the relatively old age of eight years is impressive. It may even be usual that one of a pair of twins begins with or early acquires a physical or temperamental advantage which gives him a different status in the social situations of life; and initiates a differentiating process which waxes with what it feeds upon. But in the present instance, such a strong differentiating tendency has not become very apparent. I should not be willing to say that it will never come into power. We have already suggested the differentiating possibilities of a wide difference in vocational or social careers. Even now a consistent partiality for one child on the part of the mother, a physical accident or an unshared illness, or an emotional crisis limited to one child, might become the germ for a pronounced differentiation of personalities. But on the whole, the equalizing factors have hitherto with A and B remained dominant.

Among these factors we should mention a pleasant degree of jealousy and emulation. Neither wishes to be out done by the other. For example, when at the age of seven I gave them the delightful privilege of filling my hod with chunks of cannel coal, they both insisted that they be permitted to put on the big gloves and that they also be permitted to put exactly the same number of chunks into the hod. This propensity, which fundamentally is

hereditary, has preserved a kind of balance of power and has helped to impress a certain identity on their respective personalities. Neither has become a leader of the other.

The argument that similar experiences have made these children similar does not bear close scrutiny; experience, after all, is a descriptive term for the reactions of an organism to its environment. As Dewey puts it, the combination of what things do to us in modifying our actions, and what we can do to them in producing new changes constitutes experience. From a clinical point of view, the experience argument begs the question. What we really wish to know is to what degree have these children actually had similar experiences. Our conclusion is that they have manifested similarity of experience to a remarkable degree, due primarily to the structural parity of the nervous system with which they were endowed. A similarity of environment has developed a corresponding functional parity. But here again the considerations become involved; for this so-called similarity of environment has consisted not only in the same house, similar beds, similar clothes, similar food and identical instruction; but the twins have had each other, and each has carried around much the same environment, because each apparently assimilated much the same things for her milieu. There has at least been a high degree of reciprocity between nature and nurture!

(*To be concluded.*)

# DEHYDRATION AND THE PRESERVATION OF FOODS

By Dr. HEBER W. YOUNGKEN

PHILADELPHIA COLLEGE OF PHARMACY AND SCIENCE

THE possibility of partaking of strawberries and apples in regions of the earth remote from their native habitats and districts of production at first thought seems unlikely. Upon later reflection, however, the likelihood seems possible, since we realize that they may be canned, dried or even refrigerated. But the chance of being able to have them in a condition almost like that in which they would appear when gathered in fresh from the garden or orchard and placed on the table with little or no natural flavor removed, after transportation to either of these remote points, is a far different proposition. Yet I hope to show before the conclusion of this article that the ingenuity of man has made it quite possible to enjoy not only the full flavor and flesh of strawberries and apples in arctic or torrid climes, but in addition other fruits, vegetables and meats which are not produced in these regions.

The whole secret of being able to procure the kind of food you want where and when you want it is in its preservation. The reasons foods do not normally keep indefinitely are partly biological and partly chemical. The chemical agents responsible for food spoilage are called enzymes, the biological agents, microorganisms. All living cells of plants and animals normally contain enzymes that possess the power of changing substances insoluble in water into water-soluble substances without themselves suffering any change during their term of activity. These enzymes are produced by the living matter of the cell and remain active after the death of the cell. Some of them have the power of attacking carbohydrates such as starch or inulin, breaking these substances down into water-soluble sugars, others attack proteins such as albumens and globulins, splitting these up into water-soluble peptones, etc., still others attack fats breaking them down into water-soluble fatty acids and glycerin. Some of the enzymes are present in the cells of the food itself, others occur in the cells of microorganisms which attack food. All enzymes require a certain amount of warmth and the presence of water in order to get in their activity.

From the earliest period of the human race of which there are records man has striven to preserve foodstuffs available in season and region of abundance for use in times and places of scarcity. The ancients practiced sun drying of food on a large scale.

The following are the methods chiefly employed in the preservation of foods: (1) Drying, (2) Salting, (3) Pickling, (4) Smoking, (5) Refrigeration, (6) Canning, (7) Dehydration.

### Drying of Food

The methods upon which foods are dried are based upon the principles that sufficient heat kills enzymes and the removal of water inhibits the growth of microorganisms, as well as prevents enzymic activity. In some instances, protective layers may be formed through drying by changing the former relationships of tissue constituents. Thus, for example, in the curing of pork, the fat, which is for the greater part isolated in distinct cells, becomes diffused throughout the outer layers of the flesh and forms a water-proof exterior to the ingress of microorganisms.

The removal of water in foods to an extent below the minimum required for the growth of microorganisms is secured in a number of ways. The most common ones are the uses of heat either in the form of sun's rays or from an artificial source. Sun drying is the oldest of these. In regions where the moisture content of the air is low, as in many of the fruit districts of California and other western states, exposure to the sun's rays accomplishes rapid drying. In this method insects and dust frequently have full access to the food. In more humid localities and with other types of food artificial heat is employed and so we have kiln drying and drying by means of centrifugal action. Kiln drying is much employed in the preparation of evaporated foods. In this method materials are laid on a screened floor under which heating appliances are built. The mass of material is stirred up occasionally during the drying. Drying by heat always results in concentrating the solutes. The acids in the juices of many fruits, when concentrated, may be antiseptic, *i. e.*, retard the growth of microorganisms. Frequently the sugars present reach so great a concentration as to plasmolyze the cell contents of any microorganisms present and so prevent their multiplication.

The disadvantages of all these methods of drying lies in the facts that they are slow, not all materials can be so treated and the products resulting do not regain their natural appearance, odor or taste when prepared for diet.

### Salting

This is a method of preserving meats and fish. It has been

used for many centuries and next to drying is the oldest process known. It is dependent upon the principle that salt abstracts water from the tissues of the fleshy food and so causes a concentration of the solutes within the cells too great for the growth of bacteria. It gives the food a paler color and extracts at least 25 per cent. of the protein content. The great disadvantage in this method is the danger of undersalting or oversalting. Undersalted foods putrefy in time. Frequently the putrefaction is masked and ptomaine poisoning occurs after eating these. Oversalting destroys the natural flavor and extracts much of the nutritive substances.

### Pickling

Pickling consists of the preservation of food in brine containing varying percentages of salt, vinegar, weak acids and occasionally condiments. Many foods such as olives, cucumbers, cauliflower, beets, and some meats and fish, are preserved by this method. That pickling is not always a safe method of food perservation has recently been emphasized by many outbreaks of botulism poisoning from pickled ripe olives.

### Smoking

This is a method of preserving flesh foods and flesh derivaties such as meat and fish. It consists of first placing the fleshy food in brine with or without condiments for a week or longer. A smouldering fire is then built in a specially constructed chamber. The flesh foods are taken out of the brine and hung up, being exposed for varying periods of time to the wood smoke and heat. The volatile substances in the wood smoke such as creosote, acetic acid and other germicidal substances penetrate the food at least superficially and either kill any putrefactive organisms present or retard their growth.

### Refrigeration

Refrigeration is a method of preserving foods which is based upon the principle that cold inhibits the activity of microorganisms. During the past two decades it has revolutionized the meat and eggs industries. In the meat industry it permits slaughtering to take place all the year round and great cargoes to be transported in refrigerating chambers across oceans and continents and through equatorial regions not much the worse for the transporting.

Foods preserved by refrigeration generally command a higher price than those preserved by other methods. This is in part due to the fact that the general appearance of cold storage food resembles that of the perfectly fresh article. In numerous instances, also, refrigeration, for a reasonable length of time, preserves not

only the appearance but also the delicate flavor, chemical composition and nutritive value of the original articles.

During the storage of food it undergoes some loss of water and volatile principles by evaporation and various volatile principles may be absorbed from the air of the storage room. But by far the most important point to be considered in this connection is the behavior of the biologic content of the food during this period. It should be emphasized here that refrigeration not only impedes the growth of microorganisms, but tends to preserve them as well. In addition to the organisms present in the food when it is stored, other microbes such as bacteria, yeasts and molds, may gain access to the food from time to time either by actual contact with other things or through the circulating air within the cold storage chamber.

As to whether these implanted forms will survive depends upon their nature and ability to adapt themselves to the conditions existing within the stored food. Some perish, others may survive in the passive condition, still others may survive in their active form, multiplying rapidly. It has been known for some time that some bacteria can grow at a temperature of zero and that many can reproduce at a fraction of a degree above that point. If microbic activity is, therefore, to be inhibited, the food must be frozen.

Methods of refrigeration vary depending upon the article to be refrigerated. In the production of chilled meats, the flesh of mammals is first placed in a cold chamber at a temperature of about $+2^{\circ}$ for the first 48 hours and then stored at a temperature of $+1^{\circ}$ or $+2^{\circ}$ if chilled meat is desired. During the chilling process the enzymes of the dead flesh and bacteria present are active, bringing about a ripening or curing, which makes the meat more tender and gives it a more desirable flavor. If the chilling process be allowed to proceed beyond the point where the muscle sugar is nearly completely fermented, the changes in the meat due to the decomposition of proteid material by bacterial enzymes makes it dangerous and unfit for consumption.

In the preparation of frozen meat, the dressed article is chilled in an air-chamber at $-20^{\circ}$ until it is frozen solid and later kept at a temperature below $-4^{\circ}$. Such meat remains practically unchanged for long periods. The difficulty arises when it is thawed. If warmed slowly the melting water crystals are absorbed by the protein material and the original structure of the flesh restored almost completely, but bacteria are always bound to enter in a prolonged process of this kind and cause some decomposition. In order to prevent this, the thawing is usually carried on rapidly and so the normal structure of the meat is not restored. It is

softer, darker and moister than chilled or fresh meat and prone to rapid decomposition if kept at room temperature for even short periods.

In the refrigeration of fish and poultry, these articles are chilled by packing in ice immediately after death and frozen as rapidly as possible. In thawing similar changes take place as in frozen meat but the bacterial decomposition proceeds more energetically. After thawing is complete the products spoil rapidly.

Eggs should be stored at a constant temperature which should be between +0.5° and +1° and at a constant humidity of 70 per cent saturation, if superior results are to be attained. But even with the best of control and precautions there is some deterioration in the cold storage article due to the facts that the enzymes within the egg are not necessarily inhibited nor is the growth of all of the bacteria prevented.

Milk is more rapidly changed by bacterial activity than any other food. In up to date dairies it is therefore cooled immediately after it is drawn from the animal and kept at a low temperature until delivered to the consumer. But even at this low temperature the milk bacteria multiply slowly. Freezing alone prevents their multiplication. If the milk is very clean, however, it may be kept sweet for several weeks at a temperature slightly above the freezing point.

Fruits and vegetables are refrigerated at a temperature slightly above zero and at a constant humidity of about 60 per cent. saturation. In spite of modern methods of refrigeration it is not practicable to ship fresh sea foods to distant inland towns or to send some perishable fruits and vegetables of the tropics to colder climes.

## Canning

Canning is a method of food preservation the principles of which include the destruction of microorganisms which produce the fermentative and putrefactive changes by heat and subsequently sealing the container to prevent the access of more microorganisms.

The principle of employing heat in the preservation of food had its origin in the experiments of Spallanzani, who in 1765 boiled meat extract in flasks for an hour and hermetically sealed them, after which no change took place in the material. Spallanzani, however, was not aware of the real cause of these changes.

About the middle of the nineteenth century, Tyndall and Pasteur successfully demonstrated that living microorganisms were always found where fermentation and putrefaction took place, that these organisms could be killed by heat and that if substances

liable to decomposition which had been sterilized by heat were kept so that no organisms could gain entrance, they would keep indefinitely without spoiling. But long before the causes of fermentation and putrefaction were known canning was discovered.

During the Napoleonic wars the French government faced the problem of maintaining an adequate supply of food for their army and navy and offered a prize of 12,000 francs to the person who could invent the best method of preserving food. Stimulated by this offer, Nicholas Appert, a Parisian confectioner, undertook the task. After several years of ardent investigation he discovered a method which he submitted to the Minister of the Interior. A number of substances which Appert had preserved including meat, vegetables, fruits, milk and soup were examined by the Bureau Consultif, a commission appointed by the minister, which included such men as Gay Lussac, Bardel, Scipion-Perrier and Molard.

This body reported that when the jars were opened after several months, the foods were found to be perfectly preserved and in every way satisfactory in flavor and appearance. On the strength of this report, Appert was awarded the prize of 12,000 francs. It was not until the following year (1810) that Appert published his discovery under the title of "L' Art de Conserver pendant plusiers toules les substances animal et vegetables" ("The Art of Preserving Animal and Vegetable Substances.")

Appert's method consisted of enclosing food in glass jars which were then corked tightly, placed in a bath of boiling water the time varying according to the article treated and taking the jars from the bath at the prescribed time and in a proper manner. Appert later used tin cans as containers. The success of his method was dependent upon sterilization and the absolute exclusion of air. These same principles are applied in the canning of to-day.

From France the canning method was introduced into England by Peter Durand, who in 1810 obtained a patent from the English government for the preservation of a variety of food in hermetically sealed tin cans and glass jars. Among the first to introduce the process into the United States were Ezra Dagget and Thomas Kensett, who in 1819 began to manufacture canned oysters, lobsters and salmon. In 1820 William Underwood and Charles Mitchell opened a canning factory in Boston, where they packed currants, plums, quinces and cranberries.

Enormous losses were experienced during the early years of the canning industry due to the defective nature of the square tin cans. The square can finally gave way to the economically superior round can. A press for manufacturing can tops was invented in 1850.

In 1883 a hand capping machine was patented and later various other kinds of machinery replaced hand labor.

The Civil War did more to stimulate the canning industry in America than any other factor. To-day it is recognized as the main method of preserving foods in this country and likewise the most popular.

### Disadvantages of Canned Foods

It is a well-known fact amongst chemists and physicians of to-day that the heat necessary to bring about the successful sterilization of milk, fruits, vegetables and meat destroys vitamines. These vitamines are regarded as absolutely essential for the growth, development and protection of the body against certain diseases such as scurvy and beri-beri.

In writing on the vitamines, Colonel Vedder, M. C., U. S. A., states: "It should also be noted that all canned foods must be regarded as possible beri-beri producers. It has been shown by numerous investigators, including the writer, that heating to 120°C. destroys the beri-beri preventing vitamines in certain foods. All protein foods that are 'canned' must be subjected to about this amount of heat in order to kill all the putrefactive organisms and such canned foods are, undoubtedly, beri-beri producers when used in excess."

I have recently been informed by Mr. P. R. Buettner of Danbury, Connecticut, that canned tomatoes retain some of their natural vitamines due to the protective power of the acid in this fruit during processing.

The second disadvantage of using canned goods is in their great cost of production. From four to seven ounces of tin plate are used for each container. To this must be added the cost of packing cases and the handling, canning and transportation of much water. A third disadvantage is the fact that they have limited keeping qualities. There is always danger of crushing and spoilage in transporting them. Moreover, most of those products, when prepared for the table do not possess the same appearance, odor and taste as those of the freshly prepared articles from the field or garden.

### Dehydration

Dehydration in the modern sense of the term may be defined as the process whereby perishable foods with or without previous treatment are subjected to the action of carefully regulated currents of air in which the temperature and humidity are properly controlled.

The method results in the food products gradually losing water,

but without giving up their color or flavor or having their cellular structure impaired. Accordingly, the dehydrated food will reabsorb water, swelling up to its normal size and appearance. When cooked it will have the same appearance, flavor and odor of freshly cooked material made from fresh vegetables.

Dehydration dates back to 1850, when Masson, a Frenchman, dried a large number of vegetables and fruits with a blast of warm air at temperature near 70° C. Sometime later, Passburg of Berlin obtained excellent results with vacuum drying apparatus. It was not, however, until the Boer War that products of this nature began to be manufactured on a considerable scale. During this period many thousands of pounds of dried vegetables, mixed so as to form a basis for an easily prepared soup, were produced in Canada and shipped from there to the British Army in South Africa.

Stimulated by the possibilities of marketing products of this nature on a commercial scale, a number of Americans established factories in this country and by 1910 began to manufacture dehydrated vegetables and soup mixtures. These products, however, never became popular, partly because they were not quite equal to the fresh article when cooked and partly because of the great popular demand for canned foods.

War is without doubt a great stimulator of human ingenuity, no less in perfecting methods than in inventing new ones. Just as the Civil War stimulated the introduction of new methods in the canning industry, so the World War established new methods and perfected older ones in the dehydration industry. With the problems of supplying our armies in distant fields and our ships in foreign seas with a variety of foods, and the limit of our tonnage, the food situation became acute. More and more demands were made by the government for dehydrated products in order to save transportation of water and to provide our fighters with fruits and vegetables that could not be obtained in England and France. Thousands of tons of these foods were shipped abroad during the war to the forces of the United States as well as the Allies.

It was the dehydration process that probably enabled Germany to maintain her food supplies during the war. That it was successful in that country can not be doubted when we consider the following statistics: In 1898 there were only three small dehydration plants in Germany. Eight years later the number in operation was thirty-nine, in 1914 it had increased to 488, in 1916 to 841 and in 1917 to about 1,900. By August 1st of this year there were 29 concerns manufacturing dehydrated fruits and vegetables

in the United States. To this may be added at least a dozen firms who manufacture dehydrated animal products.

The methods of dehydration employed at the present time are varied in details of procedure. All, however, are founded on the same basic principle, namely, to remove the water contained in and between the cells of the food so as to obtain a product which can not spoil as a result of microbic or enzyme action.

The water taken away by these methods is only replaceable water and so the nutritional value of the food has not been altered. Moreover, if dehydration is applied while the fruits, vegetables or animal products are absolutely fresh, the flavor-giving substances are preserved intact. In the best grades of dehydrated products the rate of evaporation is such as to bring about the removal of water without rupture to the cell walls.

By means of this process the weight of the food is reduced from 80 to 90 per cent. and the bulk is diminished to one fourth or one sixth of the original volume. By means of compression the nearly dried material may be brought to a compact form as, for example, in the Veco products. Not all the water is removed, the amount remaining varying depending upon the character of the food to from 7 to 15 per cent. But sufficient is removed to concentrate the solutes to the extent of producing plasmolysis.

The manner in which the material is prepared influences to some extent the quality of the product. If the first temperature applied to the fresh material is too high, certain changes take place in many vegetables giving them an appearance of scorched or scalded substances and diminishing their water-absorbing power. Accordingly, in dehydrating vegetables, the fresh material should be subjected to air having a low temperature and high humidity and gradually brought to a high temperature and low humidity.

## Methods of Dehydration

The methods of dehydration employed at the present time are as follows:

(1). Tunnel Systems. These consist of long chambers or tunnels into the end of which the fruits or vegetables are introduced on screens or racks and through which a strong current of dry air is blown. While there are several modifications in the arrangement of the screens and in the method of heating and driving the air, it may be said that in general the heat is supplied by coils of steam pipe and the air is forced in by powerful fans. In some plants the racks of vegetables are placed on trucks which run on tracks, so that the material is introduced at one end of the tunnel where the temperature is low and humidity relatively high, grad-

ually moved on to where the temperature is higher and the humidity relatively lower and delivered at the other end in dry form. By this means the moisture is uniformly extracted by capillary attraction without destroying the cell structure. On account of the gradual reduction of the moisture content, the cells shrink slowly without breaking down and the product retains all of its natural flavor, color and food value. In other plants the tunnels have side openings where the trays are inserted and removed by hand.

In the Hammond tunnel system, the patents of which are owned and controlled by the Unted States Dehydration Company of Denver, Colorado, the prepared fruits, vegetables or animal foods are placed in a rectangular tunnel and gradually conveyed through it, the moisture, temperature and rate of air flow all being properly coordinated. The air is allowed to take its course straight through, passing over the top of the trays or underneath them. Most of the products are steam blanched or dipped in hot water before being introduced into the drier which operation has been found quite necessary in preserving the color and keeping qualities of vegetables.

The Cook-Kelly process employed in the manufacture of "Cookelized foods" is another of these tunnel systems. In preparing foods by this process, fruits and vegetables are brought into the factory and washed, peeled, pared, sliced, cubed or riced, put on wire screen trays and placed in a rectangular tunnel approximately 35 feet long. Heated air is blown through this tunnel, the currents of this air taking the form of a sine curve as they go upward through one tray and downward through the next and so on. The trays are shoved along periodically which causes the air to reverse its passage through the products on the tray from time to time, evaporating the moisture from the products and carrying the moisture off through the other end of the tunnel.

(2). Vacuum Methods. These have been employed with success in the dehydration of fruits, vegetables and animal products. The apparatus consists of a heavy cast iron chamber containing a large number of steel shelves heated either by steam, hot water or electricity, a condenser and a vacuum pump to exhaust the air from the chamber and maintain a high vacuum on the system. The material to be dried is placed on flat screens which slide into the shelves. Heating is partly by conduction from the metal trays and partly by radiation from the next shelf above. The temperature is regulated by a thermostat, so that overheating is impossible. Through the constant application of a vacuum to the process, the water vapor is removed and the material dehydrated.

This method is particularly advantageous for the dehydration

of potatoes and apples or other vegetables containing an oxidase ferment. It is this ferment which causes the darkening of such materials when their flesh is exposed to the air. Since air is removed from the chamber no darkening results by this process. However, if such vegetables are subsequently placed in water, darkening will result, since the ferment has not been entirely destroyed. This is overcome by blanching or steam treatment before the foods are dehydrated. In the dehydration of milk and eggs by the vacuum method, heated rollers are employed. These, with various attachments, are enclosed in a chamber in which a high vacuum is maintained. The heated roller picks up a film of egg pulp or milk which dries rapidly under reduced pressure and is continuously scraped off by a knife as dried flakes or powder. In the dehydration of meats, this method is probably unequalled by any other one in its effectiveness. Large steaks and chops can be handled without oxidation and completely dried. The fats remain white and are not melted. The product is essentially raw meat with water removed. Usually a temperature of 130° F. is employed. Fish, lobster, meat, clams, oysters, shrimps and other protein foods that ordinarily putrefy easily can be preserved in excellent form by this method. Since these products are dried to about 30 to 35 per cent. of their original weight, the concentration of the solutes is too great to permit bacterial development. Most fruits and vegetables require higher temperatures than those to which flesh foods are subjected when dried by this method. With some of the products this method gives good results but is rather severe with others, tending to break down their cellular structure.

(3). Kiln Method. In this method of dehydration, square chambers with sloping roofs and perforated floors are utilized. The floor is heated from below by a stove or furnace. The materials to be dehydrated are spread on the floor to a depth of four or six inches. The hot air from the heating device passes up through the vegetables, removing the moisture, which is conducted through a ventilator in the roof. The mass of vegetables is turned over now and then by men with shovels during the drying. The advantage of this method is mainly its cheapness. The disadvantages are those of overheating or underheating. However, a number of products made thereby have proven satisfactory.

(4). Special Dehydrators. A number of special types of chambers or machines are now in use, differing from those previously considered only in certain details of construction. Many of these have appliances to carefully regulate the drying.

### Keeping Qualities of Dehydrated Foods

That dehydrated foods will keep for a long time, if properly

prepared, is evidenced by the following occurrence: During the Boer War the British Army in South Africa was supplied with thousands of pounds of dehydrated vegetables mixed so as to form the basis of a quickly prepared soup. At the close of the war one of the Canadian manufacturers was left with 30,000 pounds of this mixture for which he could not find a market, probably due to the fact that consumers much preferred to buy such vegetables in the recent condition. He placed it in barrels which were paraffined and stored it away. Fifteen years later, after the outbreak of the world war, these were shipped to the British Army in Europe and used in the preparation of soups of splendid quality. If dehydrated foods are properly prepared and kept in paraffined containers free from insect pests and ingress of moisture, there seems to be no reason why they should not keep for indefinitely long periods.

### Advantages of Dehydrated Foods Over Other Preserved Products

Dehydrated foods are superior to dried or evaporated articles because they regain the natural appearance and keep the natural odor and taste of the fresh articles when prepared for the table. Moreover, they have better keeping qualities.

Their advantages over refrigerated articles lies in the saving of cold storage charges, in the lessened transportation charges and in their superior keeping qualities. Their advantages over canned foods lie in the great saving in freight charges (since the water content is reduced to 5 or 10 per cent.), in their freedom from spoilage, their greater ease of handling, their superior keeping qualities, and in the cheap containers that may be used. Moreover, there is no danger of botulism, nor are any of the vitamines destroyed. Dehydrated foods can be shipped to any part of the globe without deterioration.

### Possibility of Dehydration in the United States

While much has been accomplished in the field of dehydration in the United States since the beginning of the world war, the surface has only been scratched. A goodly number of vegetables, fruits and a few animal products are being dehydrated successfully while scores of others have not as yet been taken up. Each kind of vegetable or animal food must be studied separately in order to properly perfect its best means of drying by this method. Dehydration is destined to stabilize the crops of the nation. Year after year, decade after decade, we are confronted by either feast or famine in respect to certain fruits or vegetables.

A good crop one year with correspondingly low prices has often been followed by a small crop the following year with high prices.

With an extension of this industry the surplus of years of great yield can be stored and made available in later years when prices are higher and the crop leaner. In a short time the amount of planting would be equalized and all would be able to secure an adequate supply of these foods at normal prices.

Again, dehydration is destined to conserve food materials. It is a notorious fact that about half of the perishable fruits and vegetables grown in this country is wasted annually on the farm, at the freight station, in transit or in the hands of the commission merchant both as a result of poor transportation facilities and irregularities in marketing.

According to the *Los Angeles Examiner,* "only 40 per cent. of the California products contributed to relieve the famine sufferers in China ever reached them in edible condition." "Had the wasted 60 per cent. been dehydrated, it would not have failed of its merciful purpose."

Again, on account of the strict grading laws enforced by the Potato Growers' Association, it is estimated that about 50,000 bushels of No. 2 undersized, sound potatoes are annually lost to farmers. The potato dehydrating industry is comparatively recent in America and dehydrated potato flour is being manufactured from some of the previously wasted material. With the spread and development of this and other allied industries much of what had previously been wasted will be conserved for the benefit of the people. The dehydration of the sugar beet and the banana offer wonderful possibilities in this direction.

It is conceivable that dehydration, now in its infancy, will within the next decade, when the nature of its products become more generally known, rival, if not outstrip, the other processes of preserving foods.

# A PERPETUAL SUBMARINE WAR

By R. E. COKER

ASSISTANT, IN CHARGE SCIENTIFIC INQUIRY, U. S. BUREAU OF FISHERIES, WASHINGTON, D. C.

NATIONS of men have battled with each other until they have become weary of war. Now they declare war against war. The recent world struggle, with all its consequences to every one concerned, was enough to reveal the folly of internecine strife. Besides, is it evidence of our boasted wisdom for groups of men to contend in mortal combat with one another while engaged against a common enemy? For all men are allies in a warfare more enduring than the disastrous conflict recently precipitated by the Central States of Europe, more wide-spread and pervasive in its actions, and at least equally critical in its bearing on the survival of the human race.

Our opponents in this war are small of stature, but in numbers they are legion. Conspicuous among these unrelenting adversaries are the tribes of insects. They, as well as others, wage war unceasingly upon us: they besiege our crops, they attack our buildings and our clothes, they destroy our animals, and they even attack our bodies with their poison darts, planting in us the germs of such diseases as yellow fever, typhoid, typhus and bubonic plague. It is like the war that Whitman sings of—"a longer and greater one than any, waged * * * with varying fortune, with flight, advance and retreat, victory deferred and wavering, and yet, methinks, certain, or as good as certain in the end." But—

Assuming that the worst came to the worst, that the insects had acquired mastery both on land and in the air—still we might retreat to the waters hoping to build submerged and protected homes. Should we find safety there? It is true insects are almost nonexistent in the sea, but they may have submarine allies. At any rate, we find there other dangerous enemies. Such are the boring animals of various groups which attack submerged structures of wood and even those of stone.

The principal naval powers opposing us are the shipworms, which, of course, are not worms at all, but rather are mollusks and not distantly related to the luscious oyster. It seems remarkable indeed that an animal of such ingratiating qualities and gentle habits as the oyster should have a near relative of even milder appearance which eternally engages in destruction of the property

of man. New piling placed at great expense may be destroyed within a period of comparatively few months. Large and expensive buildings may be brought to collapse. Vessels of wood may be so weakened by the ravages of shipworms as to fall an easy prey to storms. Of course, the harm done by shipworms is often anticipated and such measures taken that the ships, buildings and wharves do not collapse, but these preventive measures are effected only at an annual expense which in the aggregate is enormous. The damage accomplished by shipworms each year can hardly be estimated, but when we are told by a reliable engineer that in the northern area of San Francisco harbor alone, the damage by marine borers made evident within a period of two years was estimated by competent engineers to be in excess of 15 million dollars, the imagination can frame some picture of the total losses in all parts of the world—to say nothing of the costs of defense in harbors and at sea.

What is this powerful submarine enemy called by so impotent a name as "shipworm?" If we can imagine an oyster having a very small shell, about the size of one's little finger nail, but with the body projecting from the rear end of the shell for a distance equal to the length of the finger or even of the whole arm, we have a very rough picture of the shipworm. The portion of the body protruding from the shell, practically the entire animal indeed, is surrounded by an extension of the soft mantle which lines the shell. Thus the animal is in the shape of a long tube, having the shell at one end and at the other two small tubular openings called siphons. No matter how far the shipworm may burrow into a plank or a log, the little siphons remain always at the outside pinhole opening through which the animal began its travels and destructive action in the wood. It is through these tubes that the Teredo breathes and derives the greater part of its food. Through one tube a stream of water steadily flows in, while through the other it flows out. In course of its passage through the animal the water bathes the small blood vessels, bringing in fresh supplies of oxygen and taking away the waste gases; it is also thoroughly filtered, yielding up to the animal the minute microscopic organisms and detritus required for food.

It is not strange that this mollusk lives so largely outside of its shell inasmuch as its life in burrows in the wood diminishes the need for a protective shell. Such of the shell as it retains about the forward end of the body is modified to form a grinding organ which is much more effective in its operations than one would suspect from a cursory examination. The shell is marked with ridges that in reality are composed of fine sharp teeth like those of the surface of a rasp. The two halves of the shell are not fitted to-

gether like those of a clam, where there is a hinge with an elastic ligament that keeps the shell valves apart except when they are drawn together by two strong muscles that pull together, one being near each end of the shell. In the shipworm the valves of the shell are pivoted above and below and while there are two muscles, as in the clam, it seems that, instead of pulling together, they contract alternately. The alternate action of the muscles therefore throws first the front edges of the shells together and then the rear edges. It is this rocking movement of the two parts of the shell which causes the rasp-like shell to grind away the wood ahead.

These little destructive carpenters are not known to be governed by any union rules but they grind away industriously and at least make a living at the job. For them indeed it is a living wage or death. If one puts an ear upon the surface of a piece of wood in which they are working, the rhythmic rasping sounds heard may give the impression that some creatures within are sleeping soundly. The impression will be erroneous; the sounds indicate merely that shipworms are doing a day's work for a day's wage.

Much of the fine sawdust produced by the rasping of the wood is taken into the stomach along with the living organisms from the water and it is yet a disputed question to what extent shipworms actually feed upon the wood which they continually grind up. To a large extent surely they feed upon organic matter, living or dead, which is carried in the sea water; this they strain out, as previously indicated, while the stream of water passes through their gill plates.

So far we have spoken of shipworms as if they were of one race or tribe. As a matter of fact there are several kinds of boring mollusks called shipworms besides boring animals of other groups. The principal boring mollusks belong to one family which scientists have maliciously named Teridinidæ. There are some boring mollusks which do not belong in the typical shipworm family. Among these is one called Pholas which bores in rocks such as limestone and sandstone, and occasionally wood, but never in hard or compact rocks. Another, euphoniously named Martesia, is found in timbers of wooden ships in West Indian waters. Xylophaga, which is not, as might be thought, a musical instrument, really accomplishes serious damage to marine structures and to the covering of submarine telegraph cables.

Giants among shipworms are the plumed pile-worms[1] which may be three feet in length and have a head diameter of nearly one inch or approximately the thickness of the human thumb. They are said to burrow at the rate of ⅛ inch a day; thus it can be seen that a great deal of damage can be accomplished by a few individuals in course of a few weeks. The increasing effectiveness

of the attack may be appreciated when it is considered that they begin breeding at the age of 30 days and that a single healthy mother may cast millions of eggs into the sea water.

But the real king of the shipworms is the pet of our South Atlantic Coast, sometimes known as *Teredo dilatata*. A female which attains a length of 4 feet and a head diameter of 1 inch has the right to her "big head" for she lays one hundred million eggs at a sitting—enough to fill 4 or 5 thimbles. This apparent enormous waste in egg production is rendered necessary because great quantities of eggs or larvæ may be destroyed in the first few hours of life by physical conditions existing in the water or may be consumed as food by innumerable small floating animals.

The "shipworm" of the dykes of Holland[2] is less properly so called because it is not so often found in the timbers of ships as are other species. Its burrows are smaller and more symmetrical and regular than those of the giant pile-worm. It lives and dies within a year. The eggs are said to be held within the body of the maternal parent while they develop into free-swimming larvæ that subsequently escape into the sea. They are believed to remain in this free state about a month, during which they develop a "foot" and a pair of shells, before they settle down on wood and transform into the boring adult form. The number of eggs is estimated at a little less than two million. The free-swimming habit of the larvæ of this shipworm, and of the eggs and larvæ of those previously mentioned, is most significant because it enables the juvenile shipworms to travel long distances with the currents of the sea and thus to invade new territories.

The burrow of a shipworm enters the wood at right angles to the surface as a small pin hole, but soon turns and traverses it obliquely or parallel to the surface and usually downwards. The shipworm never bores completely through the wood but, guided by some instinct, the nature of which we can not define, it turns away just before breaking through the inner face of the wood. If, however, shipworms do not make a perforation completely through the bottom of a vessel they may so fill it with their burrows as to leave little more than an empty shell that is easily broken through by any blow or direct pressure.

Not all marine borers are shipworms. Any boy who has turned over a log of wood in the yard or in the forest may have observed the small "pillbugs" which live beneath the wood. These are crustacea belonging to the same large group of animals to which pertain the crabs, shrimps and lobsters. If a pillbug is left undisturbed for

[1] There are distinct species of this genus on our two main coasts, *Xylotra setacea* of the Pacific and *Xylotra gouldi* of the Atlantic.

[2] *Teredo navalis*.

a few moments it will be observed to unroll itself to assume a flattened form and crawl away. It might interest this boy to know that the pillbug has a relative in the sea called gribble (scientists call it *Limnoria lignorum*) which creeps into small crevices of wharf piles, even those which have been treated with creosote for protection, and, by gnawing away the wood, creates burrows which, when made in large numbers, will soon reduce the creosoted pile to an hour-glass shaped peg. The young have no free-swimming stage but, as soon as they leave the mother, begin to "dig in" for themselves. Hence they form family communities, and new colonies no doubt arise by the drifting of crumbled portions of pile to places where new homesteads may be established. A single square inch of wood has been found to contain nearly 400 individuals, adult and young. Another pillbug borer (Sphaeroma) digs into mud, wood, or even rock itself, but it seems to dig for shelter, not for food. Some of these are known to destroy piling in fresh-water.

Again, there is the feathered crustacean borer, called *Chelura tenebrans,* which works along with the pillbug borers and is known as a destroyer of wood both in Europe and North America. It is related to the familiar sand-hoppers or beach-fleas, though it has some external resemblance to the pillbug borers.

Our tale might be interminable if we proceeded to tell of the boring worms and the little sponges that make the familiar holes in the shells of oysters as well as in rock structures composed of limestone and that are of more economic importance than might at first appear. There are barnacles, too, that bore into limestone and coral.

Perhaps most interesting of all to the collector are the several kinds of boring clams which are often found encased in calcareous rocks. It is an exhilarating surprise to break with a hammer what appears to be a solid rock and in smooth oval burrows find completely formed clams entombed, as it were, within the rock but in healthy living condition. The chambers in which they live will be found to be connected with the outside only by small pores through which, with the usual currents of water, the clams derive their sustenance. Some of these cavities are undoubtedly excavated by the abrasive action of the rotating or rocking shell, but others are said to be found in rocks so hard that the excavation may not be supposed to have been effected solely by the mechanical action of the fragile shell. If an acid is employed in dissolving the rock it seems remarkable that the calcareous shell of the animal is not itself dissolved, and perhaps it would be except for the protective horny covering of the shell.

It is not to be assumed that the submarine war is altogether one-sided and that man has no means of defense against the destructive

action of the marine borers. It has been held that, in some cases, at least, leaving the bark on wood piling affords some protection against borers but certainly this is a very poor defense, both because the bark itself may be attacked by borers, though they like it less than the wood, and because the bark is likely to be knocked off or cracked. It requires but a very small opening for the borers to get the first foothold after which their destructive action rapidly extends. Metal sheeting for piling is sometimes employed but a metal such as copper, which will withstand for a considerable period the corrosive action of salt water, is costly, tempting to thieves and liable to injury. Paints and treated burlap are also used but these are liable to damage from the contact of boats or drift, to the formation of cracks, and especially to injury in storms. Nevertheless there are coatings which have been found to give piling a life of 5 to 8 years. Concrete casings have been employed but great care is needed in their application and such casings are likewise subject to injury from the battering of boats against the piles.

An ingenious person once suggested the use of jointed collars of loose floats put in series around the piling with the idea that the continual battering of the floats from wave action would destroy the larvæ of the borers before they could effect an entrance into the wood. It requires, however, such a little break in the surface to harbor the minute larvæ of the borers that the plan does not seem to have been as effective in practice as it appeared to be in theory. Electrolysis and dynamite explosions have been employed for the destruction of the larvæ but the necessity of frequent repetition of the processes and perhaps other deficiences in their operation have prevented their demonstrating such results as could have secured their general adoption. For wood piling nothing more effective has yet been developed than impregnation with creosote oils which, while hot, are forced into the wood under substantial pressure. The protection afforded by creosote is, however, also limited in duration.

Of course wood may be displaced altogether for submerged structures by the use of iron or concrete, but the mechanical difficulties and the high expense of using either material are equivalent to a very high tribute paid for protection from our enemies; or, as we may prefer to put it "Millions for defense but not one cent for tribute!" Call it defense or tribute, as you please; in any event, until additional discoveries may be made, we protect our submarine structures from the depredations of marine borers only through very great expense in initial costs or in frequent replacements.

Shipworms and their allies remind one of the man who made his living suing the railroad. How did he live before the railroad

was built? Some one also asked how mosquitoes found satisfaction and profit in life before man invaded their haunts. So the question occurs: Were there no cohorts of shipworms before civilization developed to the point where men "went down to sea in ships" or built structures out into the shore waters. It must be remembered that forests and rivers are nearly as old as the sea, and there were floating logs before there were ships or the hollowed logs that served for transportation of coastal tribes of men. Nor have marine borers been altogether dependent upon the chance log that drifted into their habitat. Along the shores of tropical countries there have long existed forests of mangroves whose aerial roots hang down into the salt or brackish waters, to serve as lodging places for oysters, barnacles and other living things of the sea. Not often can a shipworm find a suitable home in the green and growing tree, but one of its "associated powers," the tribe of pillbug borers, is not disturbed by the presence of flowing sap. No matter how green the stem or root, these "shock troops" assuredly cut their trails through the bark and into the wood, causing eventually the death of the affected piece. The way thus prepared for the main forces, the molluscan borers soon fill the dead wood with their burrows, until finally it is so weakened as to fall away and bear its burden of oysters to the mud.

So when man appeared with his floating and fixed structures, the triple alliance of shipworms, pillbugs, and feathered borers, were not found in a state of unpreparedness. All the methods of submarine attack had been developed, the armies were in training and the invisible warfare began at once. "Sunk without warning" must have been the sad report of one of the early sailors of the sea.

Did the wise neighbors jeer the unfortunate victim of a bold impulse to brave the sea, or did the tribe in sympathy and alarm assemble to propitiate their god? We do not know, but we can imagine that, sooner or later, the cause was sought by some inquiring mind and that in time it was discovered that, by keeping the family log in fresh water and sea water alternately or by regularly hauling it out in the sun, the trouble was obviated—the unseen enemy defeated.

Thus began this war against war, and, as marine structures increased in number, size and complexity, new tactics of defense were evolved. And yet, here we are in the 20th century still relatively defenseless, and only beginning to realize that, did we devote one half the thought and scientific skill to the age-old submarine war that we recently did to a man-made under sea attack, we might have an earlier hope to win a battle of the ages—the battle of the borers.

# THE NEGRO ENUMERATION OF 1920

## A REPLY TO DR. KELLY MILLER

By LE VERNE BEALES
EXPERT SPECIAL AGENT, BUREAU OF THE CENSUS

IN an article entitled "Enumeration Errors in Negro Population," published in the February, 1922, issue of THE SCIENTIFIC MONTHLY, Dr. Kelly Miller asserts that the 1920 enumeration of Negroes was seriously defective, basing his assertion mainly on the fact that the rate of increase shown for the Negro population between 1910 and 1920 was less than might have been expected under normal conditions. With this utterly inadequate basis for his claims, and presumably without giving any study to data as to Negro age distribution, he declares that the enumeration of 1920, like those of 1870 and 1890, was "so flagrantly discrepant as to demand special explanation and correction." (Page 169.) Disregarding the reduction in the Negro birth rate due to the abnormal conditions prevailing during the last decade, and making no allowance for the excessive mortality due to the influenza epidemic, he estimates that the true rate of increase in the Negro population between 1910 and 1920 was 9.6 per cent., a rate which would be substantially in line with those for preceding decades. In order to obtain this normal-appearing rate of increase, he adds 300,000 to the number of Negroes enumerated in 1920, asserting that the estimated total thus obtained "makes the Negro population behave more or less normally"—despite the fact that conditions were far from normal during the last decade. (Page 176.)

As a matter of fact, a careful examination of all—not merely a part—of the available data which are sufficiently reliable to be worthy of consideration demonstrates the substantial completeness of the Negro enumeration in 1920. The evidence supplied by the census figures themselves is so convincing that there is really little need to consider collateral data. Nevertheless, the birth and death statistics for the Negroes in those states which maintain adequate registration systems have been carefully examined and have been found to be in harmony with the decennial census figures.

It was a well-known and unquestioned fact before the census was taken that there had been, during the latter half of the last decade, an unusual and very considerable migration of Negroes from the South to the North and West. The census confirmed that

fact and showed that the migration during the entire decade had amounted to about 400,000. Such a movement would naturally have a tendency to break up the home life and family relationships and result in a reduced birth rate. That this was the case is brought out clearly by an examination of the following figures for Negro children under 10 years of age:

| AGE GROUP | 1920 | 1910 | Increase (+) or Decrease (—) | |
|---|---|---|---|---|
| | | | Number | Per cent. |
| Total under 10 years | 2,409,906 | 2,509,841 | —99,935 | —4.0 |
| 5-9 years | 1,266,207 | 1,246,553 | +19,654 | +1.6 |
| Under 5 years | 1,143,699 | 1,263,288 | —119,589 | —9.5 |

There is nothing inexplicable about this condition. The departure of hundreds of thousands of Negroes, most of whom were undoubtedly in the younger adult ages, from the South brought about a material reduction in the number of Negro births in that section; but the presence of these migrants in the North and West did not result in any counterbalancing increase in Negro births. The Negro birth rate is much lower in the North and West than in the South, and in some states it falls below the Negro death rate. In 1920, of the 18 northern and western states in the birth-registration area, only four showed natural increases due to excess of births over deaths among the Negro population, the rates of such increase ranging from 1.4 per 1,000 Negro population for Pennsylvania to 5.2 for Massachusetts. The remaining 14 northern and western states showed natural decreases in their Negro population due to excess of deaths over births, ranging from six tenths of 1 per 1,000 for Ohio to 19.1 for Maine. The birth-registration area also includes five southern states and the District of Columbia. Of these, the District and four states show the following rates of natural increase in Negro population for 1920: District of Columbia, 1.9 per 1,000; Maryland, 6.4; South Carolina, 11; Virginia, 12.1; North Carolina, 15.1. The figures for Kentucky indicate a natural decrease of 1.8 per 1,000.

In order, therefore, to test the completeness of the 1920 census figures for the Negro population by comparing them with the results of preceding censuses, it is necessary to make the comparisons between the number of Negroes 10 years of age and over enumerated at each census and the total number enumerated at the preceding census. In this way the births during the decade are eliminated from consideration, and the mortality among the Negro population enumerated at the beginning of the decade is ascertained. The following table shows, for each census year from 1850 to 1920, the total

Negro population and the Negro population 10 years of age and over, as enumerated, together with the percentage by which the number at the ages of 10 and over fell below the total number enumerated at the preceding census:

TABLE 1

TOTAL NEGRO POPULATION AND NEGRO POPULATION 10 YEARS OF AGE AND OVER, WITH PERCENTAGE BY WHICH NUMBER 10 YEARS OF AGE AND OVER FELL BELOW TOTAL NUMBER AT PRECEDING CENSUS: 1850-1920

| CENSUS YEAR | Total negro population | Negro population 10 years of age and over | Per cent. by which number 10 years of age and over fell below total at preceding census |
|---|---|---|---|
| 1920 | 10,463,131 | 8,053,225 | 18.1 |
| 1910 | 9,827,763 | 7,317,922 | 17.2 |
| 1900 | 8,833,994 | 6,415,581 | 14.3 |
| 1890 | 7,488,676 | 5,328,972 | 19.0 |
| 1880 | 6,580,793 | 4,472,373 | 8.4 |
| 1870 | 4,880,009 | 3,428,757 | 22.8 |
| 1860 | 4,441,830 | 3,084,940 | 15.2 |
| 1850 | 3,638,808 | 2,500,353 | .... |

The following table gives adjusted figures for 1870 and 1890. The revised total for 1870 in the first column has been published heretofore in the decennial census reports. The revised total for 1890 in the first column is given on page 28 of the Bureau's special report, "Negro Population in the United States: 1790-1915." The revised figures for 1870 and 1890 in the second column have been

TABLE 2

TOTAL NEGRO POPULATION AND NEGRO POPULATION 10 YEARS OF AGE AND OVER, AS ESTIMATED FOR 1870 AND 1890 AND AS ENUMERATED IN OTHER CENSUS YEARS, WITH PERCENTAGE BY WHICH NUMBER 10 YEARS OF AGE AND OVER AT EACH CENSUS FELL BELOW TOTAL NUMBER AT PRECEDING CENSUS: 1850-1920

| CENSUS YEAR | Total negro population | Negro population 10 years of age and over | Per cent. by which number 10 years of age and over fell below total at preceding census |
|---|---|---|---|
| 1920 | 10,463,131 | 8,053,225 | 17.4* |
| 1910 | 9,827,763 | 7,317,922 | 17.2 |
| 1900 | 8,833,994 | 6,415,581 | 17.3 |
| 1890 | 7,760,000 | 5,525,000 | 16.0 |
| 1880 | 6,580,793 | 4,472,373 | 17.1 |
| 1870 | 5,392,172 | 3,790,697 | 14.7 |
| 1860 | 4,441,830 | 3,084,940 | 15.2 |
| 1850 | 3,638,808 | 2,500,353 | .... |

*Adjusted to exclude mortality due to influenza epidemic.

calculated on the assumption that the age distribution at the two censuses in question was the same for the Negroes omitted as for those enumerated. The revised rate for 1910-1920 in the third column has been calculated by deducting the estimated mortality due to the influenza epidemic in 1918 and 1919 (60,000) from the total decrease. The revised rate, therefore, represents the normal mortality during the decade among the Negroes enumerated in 1910.

In preparing the foregoing tables no adjustment has been made on account of the change in the census date from June 1 in 1900 to April 15 in 1910 and to January 1 in 1920, and the effect of immigration has also been disregarded. The numbers of Negro children who reached the age of 10 between April 15 and June 1, 1910, and between January 1 and April 15, 1920, were undoubtedly somewhat larger than the numbers of deaths of Negroes 10 years of age and over during the same periods. On the other hand, the number of Negroes 10 years of age and over as enumerated at each census would be reduced by the exclusion of the immigrants who arrived during the preceding decade. As it would be impossible to calculate accurately the slight effect of either of these opposing factors, they have both been disregarded; but the resultant error is too slight to have any significance as affecting the comparability of the percentages for the several decades.

The rates in Table 1 show conclusively that the 1870 returns were far from complete, and indicate that the 1890 returns were also incomplete, although not to so great an extent as those of 1870; but, as will be seen from the revised rates in Table 2, the decrease due to normal mortality in the Negro population enumerated in 1910, as shown by the census returns for 1920, was in entire harmony with the corresponding decreases during preceding decades.

It may be mentioned in passing that the mortality during the last decade among the Negro population enumerated in 1910, as indicated by the percentage in Table 1, is no more than might be expected from an examination of the mortality rates for the colored population (Negroes, Indians, Chinese, Japanese, and other nonwhites) of the death-registration area, which—excluding the abnormal year 1918—ranged from a maximum of 23.4 per 1,000 colored population in 1911 to a minimum of 18 in 1920. For 1918 the rate was 26 per 1,000. These rates do not show at all definitely the total colored mortality, since the death-registration area contains only a part of the colored population, but they do indicate that the Negro mortality during the decade was fully as great as that shown by the decennial census figures.

Thus the census returns for Negroes 10 years of age and over in 1920 not only afford no ground whatever for an assumption that the enumeration was deficient, but in large measure demonstrate

their own substantial accuracy, and therefore, in the entire absence of any credible evidence to the contrary, must be accepted. Hence if the charge that the enumeration of the Negro population as a whole was deficient is to be sustained it must be accompanied by proof of an incomplete enumeration of children under 10. No such proof has been offered. Moreover, as has already been pointed out, the unprecedented northward migration of Negroes between 1910 and 1920 resulted in a marked decline in the birth rate, and the census figures show only what might have been expected in this respect. Furthermore, it would be idle to claim that the census takers, while successful in enumerating the parents and older children, were guilty of overlooking scores or hundreds of thousands of the younger children. Such an assumption is unworthy of serious consideration. The most difficult part of the population to enumerate is made up of the roving or "floating" element, which consists mainly of unattached adults—or, at any rate, of adults separated from their families; but the enumeration of children presents no special difficulties.

In order to forestall further allegations of underenumeration based on obvious discrepancies in the statistics for certain age groups, it may be added that these have been carefully considered and are found to have no material effect on the accuracy of the returns for the total number of Negroes aged 10 and over or the total number at all ages. The number of Negro men reported as between the ages of 20 and 35 was probably too small, but the number reported as between the ages of 45 and 55 was probably too large. The obvious explanation of this condition is that there was a general overstatement of the ages of Negro men whose true ages were between 20 and 50, but the total number of men under 55, as enumerated in 1920, is not unduly small. The Negro population of both sexes in the age group 20 to 54 formed 47.3 per cent. of the total Negro population of all ages in 1920, as against 44.6 per cent. in 1910 and 41.8 per cent. in 1900. It is clear, therefore, that there was no serious underenumeration of young or middle-aged Negro men, but merely an overstatement of their ages.

Another test of the accuracy of the 1920 returns is found by comparing the sex distribution of the Negro population as shown by the last three censuses. The males outnumber the females among the Negro population of every northern and western state except New York and New Jersey; and the roving or floating element, which is by far the most difficult to enumerate, is made up mainly of males. If, therefore, there had been any considerable number of omissions in enumerating this element in 1920, the result would have been a decrease in the indicated ratio of males to females as compared with 1910 and 1900. On the contrary, however,

the returns show increases in this respect both for the total Negro population and for the Negro population 10 years of age and over, as will be seen from the following statement:

EXCESS OF FEMALES OVER MALES AND SEX RATIO IN NEGRO POPULATION: 1920, 1910 AND 1900

| AGE LIMIT | Excess of females over males | | | Males to 100 females | | |
|---|---|---|---|---|---|---|
| | 1920 | 1910 | 1900 | 1920 | 1910 | 1900 |
| All ages | 44,259 | 56,001 | 60,900 | 99.2 | 98.9 | 98.6 |
| Ten years and over | 34,301 | 43,150 | 53,784 | 99.2 | 98.8 | 98.3 |

These figures alone supply fairly conclusive evidence that there were no wholesale omissions in enumerating the migrant Negroes in the North and West.

Dr. Miller's assertion that "The internal evidence of error is overwhelming" (page 170) may therefore be reversed in meaning; for the internal evidence, when considered in all its phases, certainly sustains the substantial accuracy of the enumeration. Nevertheless, in order to make assurance doubly sure, the results of the enumeration in every county in the southern states in 1920 were scrutinized in comparison with the figures for 1910 and 1900, and a careful examination of the original returns was made for the few counties which showed decreases that appeared suspiciously large as against the increases or decreases during the preceding decade; but in no case was anything found to indicate that the enumerators had neglected to canvass the Negro population generally, or any considerable part of it.

Dr. Miller asserts that—

> ". . . . An acknowledged error of a half million [referring to the census of 1870], it would seem, would put this bureau on the lookout for similar errors in the future." (Page 170.)

And again:

> ". . . . As this bureau has admittedly committed grave errors in enumeration of the negro population in two preceding censuses, it is but reasonable that the obvious discrepancy can be most reasonably accounted for by an error in the present count." (Page 172.)

The present Bureau of the Census is in no way responsible for the errors of 1870 and 1890. The Census Office has been in continuous existence since July 1, 1899, and has been existence as a permanent office, under substantially its present organization, since July 1, 1902. Not one person connected with the census of 1870 is now in the service of the Bureau, and only a very few of the officials and employees of 1890 are in the present office.

Dr. Miller points out that the World War greatly upset the mobile Negro population, and continues:

"... There was a mad rush of negroes from the South to fill the vacuum in the labor market caused by unsettled conditions. Thousands of negro homes were broken up and their members scattered without definite residential identity." (Page 172.)

He is thus fully aware of the Negro exodus from the South, but is willing to consider it only in connection with the difficulties in the way of enumerating the migrant Negroes in their northern abodes, disregarding entirely the pronounced decrease in the Negro birth rate which resulted from this unusual migratory movement. He continues:

"In the cities especially, it seems probable that the count was greatly underestimated. The negro migrants lived for the most part in improvised lodgings and boarding houses whose proprietors had little knowledge and less interest in the identity of the boarders. The census official, visiting such boarding houses with a large number of negro boarders would, in all probability, receive an inaccurate underestimate by the ignorant and uncaring proprietors." (Page 172.)

The proprietors of lodging houses were required to do far more than make an estimate of the number of their lodgers. They were required to give the name and as many as possible of about 15 items of information in regard to each lodger whom the enumerator was unable to interview personally. Moreover, it would be an exceedingly unbusinesslike lodging-house keeper who would not at least know how many lodgers he had.

Dr. Miller quotes from an editorial in the Oklahoma City Dispatch, in which it was asserted that 33 Negroes had been overlooked in one block. During the enumeration many similar charges were made by newspapers, chambers of commerce, and other organizations, and some of them were couched in violent and abusive language. These charges were duly investigated and in most cases were found to rest upon very slight foundation or no foundation at all. A newspaper in a certain city having a population of approximately 15,000 asserted that the city had been underenumerated by about 10 per cent. In reply the Bureau offered to recanvass the entire city for the purpose of verifying or correcting the original enumeration if the editor could prove that in some part of the city, to be selected by himself, the enumeration had been deficient to the extent of 2 per cent. The editor then brought the matter to the attention of the local commercial club, which, after investigation, expressed in writing its satisfaction with the enumeration and its belief that the work had been properly performed.

In another city, whose population was approximately 23,000, complaints were made that the enumeration was "so absurd that it amounts to nothing short of an insult," that it was "absolutely ridiculous," and that the alleged errors were due to "gross incompetency of enumerators." The Bureau requested the complain-

ants to supply proof in the form of names and addresses of persons omitted. They organized a canvass of a part of the city, secured 1,239 names of persons purporting to have been bona fide residents and to have been missed by the enumerators, and sent these names to the Bureau; but from this number it was possible, through careful and painstaking investigation, to sift out only 91 names of persons who were actually entitled to enumeration and had been missed.

From these examples it is obvious that little credence is to be placed in a mere newspaper statement that the enumeration was incomplete. It is easy to assert emphatically that a city or town has a far greater population than the census returns show, and there is little difficulty in producing persons who will declare themselves to have been missed by the enumerators. But when a thorough investigation is made it is found in the great majority of cases either that the persons were enumerated without knowing it, the information regarding them having been supplied by others, or that they were not entitled to enumeration as bona fide residents of the city or town in question.

One instance of miscalculation on Dr. Miller's part is worthy of special mention, not because it has any direct bearing on his claim of underenumeration of the Negro population, but because it illustrates forcibly the lack of care and occasional disregard of mathematics displayed in the preparation of his article:

> "Even the apparent rapid increase in the white death rate awaits fuller explanation before the figures can be relied upon with assurance. It is curious to note that the birth rate among the whites in South Carolina fell from 32.3 in 1900 to 27.1 in 1919, the death rate rising but slighly from 10.4 to 10.6 during the same interval. And yet the white population of that state increased from 557,807 in 1900 to 818,538 in 1920. There was a vigesimal increment of 250,731 with little or no reinforcement from immigration. This unexplained increment in the white population seems also to discredit the reliability of the recorded mortality statistics within the states so recently added to the registration area." (Page 174.)

There has been no rapid increase in the white death rate. For the death-registration area as a whole (which has been increasing in extent from time to time) the death rate for the white population decreased from 17.1 per 1,000 in 1900 to 12.6 in 1920, and during the entire period there was no pronounced increase from one year to another, except in the case of the rate for 1918, 17.4 per 1,000, which, because of the influenza epidemic, was considerably higher than that for the preceding year, 13.7.

The increase in the white population of South Carolina is in no way inconsistent with the birth and death rates cited by Dr. Miller. In fact, although the death rate for 1900 is probably open to question (the state was not then in the death-registration area), it hap-

pens that the figures harmonize very closely indeed. The rate of natural increase due to excess of births over deaths in 1900, according to the figures, would be 21.9 per 1,000 white population, and the corresponding rate for 1919 would be 16.5. Assuming that the annual rate of natural increase in the white population decreased from 21.9 per 1,000 in 1900 to 16.5 in 1919, the decrease in the rate of increase being uniform throughout the period, the vicennial increase would be approximately 257,000, or only about 4,000 less than the increase of 260,731 shown by the census figures (not 250,731, as stated by Dr. Miller).

To summarize:

Dr. Miller's claims are based mainly on the fact that the increase shown by the Negro population during the last decade was abnormally small. He assumes that the true increase must have been a normal one, despite the fact that the conditions during the decade were abnormal.

The census figures themselves show that the number of Negroes 10 years of age and over enumerated in 1920 bears an entirely normal relation to the total number of Negroes enumerated in 1910. Furthermore, the mortality during the decade among the Negroes enumerated in 1910, as shown by the census returns, is scarcely as great as that indicated by the mortality statistics for the colored population of the death-registration area.

The returns show that the number of Negro children under 10 years of age, and especially the number under 5 years of age, as enumerated in 1920 were abnormally small. This condition was a natural result of the unprecedented Negro migration from the South to the North and West during the decade. Moreover, since the census takers were obviously successful in enumerating all or substantially all the adults and older children, there is no possibility that they overlooked a very large number of children under 10.

The ratio of males to females in the total Negro population and in the Negro population 10 years of age and over in 1920 was higher than in 1910 or 1900, the increase from census to census being substantially uniform. Thus there could have been no wholesale omissions in enumerating the migrant Negroes in the North or West, among whom the males far outnumber the females.

For the foregoing reasons the writer, after a thorough study not only of the census returns but of such available collateral data as have any bearing on the matter, is of the opinion that the enumeration of Negroes was probably as nearly complete in 1920 as in 1910 or 1900, and finds no ground whatever for attacking the 1920 census as inaccurate beyond the small margin of error which is inherent in any great statistical undertaking.

# AERONAUTIC ACCIDENTS OF TWO YEARS COMPARED

By Dr. FORD A. CARPENTER

MANAGER DEPARTMENT OF METEOROLOGY AND AERONAUTICS,
LOS ANGELES CHAMBER OF COMMERCE

ON September 16, 1919, the Los Angeles Chamber of Commerce created a department of meteorology and aeronautics and this newest creation in any commercial organization took for its motto "To make the Soil productive and the Air safe." The manager being both a meteorologist and an aeronaut has been able to apply the principles of weather science *directly* to problems of agriculture and aeronautics. The first is being accomplished through climatic surveys of agricultural districts, and the second by making all sources of meteorology available to air pilots. Realizing the necessity of accurate data on which to base the relation of weather to aeronautic accidents, statistics as to flying activities have been collected day by day from the press dispatches during the past two years. While the period is admittedly very short, it is believed that sufficient data have been collected to show the relative importance of weather elements in aerial navigation, the proportionate value of the other factors, and the comparison of these compilations one year with the other.

As has been well said: "An airplane accident is hardly ever due to a single cause. Usually several factors are involved * * * An error in judgment by the pilot is perhaps the most common cause of airplane accidents."[1] Bearing this fundamental in mind we will consider first the statistics of the year 1920-21.

Figures as to airmileage are not available, neither is information as to the airworthiness of the various kinds of aircraft, or the airmanship of the pilots: such phases of the subject, will, of necessity, be neglected in this study.

During the twelve months ending September 15, 1921, there were reported from various parts of the United States 76 aircraft accidents in which 137 deaths occurred. This was more than twice as many as occurred during the previous year. Fifty-eight per cent. of the fatalities occurred among government airmen, 31 per

[1] *Airplanes and Safety*, The Travelers Ins. Co., Hartford, Conn., 1921.

cent. in commercial flying, and 11 per cent. among spectators in ground accidents.

The classification of deaths among officers and others connected with the government shows the following distribution:

| | |
|---|---|
| Army | 59 per cent. |
| Navy | 19 per cent. |
| Air mail | 17 per cent. |
| Forest patrol | 5 per cent. |

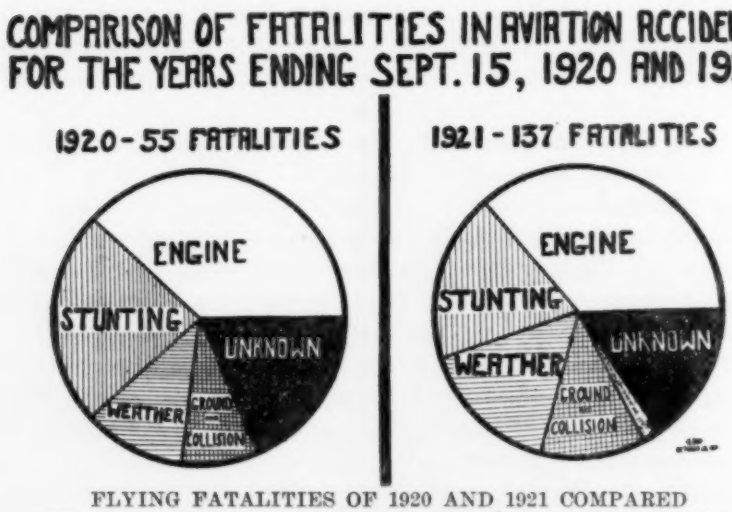
The kind of aircraft in which fatalities occurred are classified thus:

| | |
|---|---|
| Airplane | 83 per cent. |
| Seaplane | 12 per cent. |
| Balloon | 4 per cent. |
| Parachute | 1 per cent. |

Comparing the causes of all aeronautic fatalities one year with another we have this table:

| | 1920 | 1921 |
|---|---|---|
| Engine trouble | 38 per cent. | 36 per cent. |
| Stunting | 24 per cent. | 19 per cent. |
| Weather conditions | 11 per cent. | 16 per cent. |
| Collisions | 9 per cent. | 12 per cent. |
| Structural defects | 0 per cent. | 2 per cent. |
| Unknown | 18 per cent. | 15 per cent. |

Prepared by the *Dept. of Meteorology and Aeronautics of the Los Angeles Chamber of Commerce.*




FLYING FATALITIES OF 1920 AND 1921 COMPARED

The segments of the circles show the percentage of fatalities in all kinds of aviation accidents from five known and one group of unknown causes. It is instructive to note that while stunting as a death-producing feature has decreased from 24 per cent. to 19 per cent., engine trouble still remains the prime cause. The weather conditions of 1920-21 were no more unpropitous than those of 1919-20 so that the increase from this cause from 11 per cent. to 16 per cent. may be laid to the ignorance or disregard of weather indications.

As will be observed by perusing the accompanying diagrams the proportion of accidents resulting from the principal causes remains unchanged. Notwithstanding the advances made in motor construction during the past year fatalities arising from faulty engines was decreased only 2 per cent. Stunting accidents dropped off 5 per cent., probably because of the dulling of the public appetite for such acrobatics. Weather conditions are shown to be an increasing cause of accidents doubtless due to the pilots' insufficient meteorological knowledge. There were an increasing number of collisions in midair and with spectators. Structural defects, as such, first appeared last year as the cause of 2 per cent. of the fatalities.

Transportation over the sea, on the land and through the air will never be rendered absolutely safe for we have to deal with human fallibility and the changing elements. It is only needful to call attention to the fact that notwithstanding long familiarity with the water, marine accidents show little diminution in proportion to the passenger-mile. With railroads such is not the case for vigilence and scientific control have reduced fatalities most markedly during the past decade. However, that next newest method of transportation, the automobile, does not show a decrease in the number of people killed by it, but rather an increase. As to aerial locomotion, a study of accidents indicates five ways of making it safe and dependable:

1. Improve the motor in dependability; devise a new motive power if necessary.
2. Absolutely eliminate stunting by penal statute except as a military measure.
3. Educate the pilots in meteorology; make every airman a meteorologist as every mariner is weatherwise.
4. Increase vigilance in the inspection of aircraft.
5. Strict supervision of flying fields and the education of the public in their attitude towards aerial navigation.

Public confidence in practical aeronautics will come with increased safety: no other element is so vital. That the air will be made safe for general transportation is assured for the need is imperative. Time is the only inelastic thing given to man and everyday flight, outdistancing the locomotive or the automobile, is the only way in which the busy man may increase his day's work by annihilating time.

# WHY THE MOVIES MOVE

By DONALD A. LAIRD

THE STATE UNIVERSITY OF IOWA

OVER nine tenths of us are now confirmed movie goers. The remaining one tenth will without doubt soon be enthusiastic converts to the silver screen, while those few who do not attend or are not regular in their movie habits either do not know what they are missing or else it is physically impossible for them to attend.

Among the millions who are weekly movie goers there are at the most only a few hundred who understand why the pictures seem to move. Every one knows that countless thousands of pictures are flashed on the screen in rapid succession and in such wise as to produce the effect of motion. This is about the limit of common knowledge regarding why the movies move. But after you have read and understood and remembered this account of the why of the movies you may count yourself among the few hundred who understand how the effect of motion is produced.

It is easy to take things for granted without striving for an understanding of them. This is the great American characteristic. We are too easily content with a half truth or with a superficial explanation.

As adults we seem largely to have lost the thoroughgoing inquisitiveness which characterizes certain periods of childhood. Then we asked what, why, where, when, how, and ended up with why is it that way. Now as adults only a single, cursory question is asked and, lest we betray ignorance or slowness to comprehend, we let an "Oh, yes! That is so" take the place of the series of follow-up questions which should be put to clarify and explain things.

The best intellectual tonic we can experience as adults is a reversion, as it were, to this inquisitiveness of our childhood which forced us to stick to a problem until it was satisfactorily and genuinely solved or understood.

When one really once understands some of the applications of science in providing the comforts and recreations for his daily life, one comes into a realization of the wonderful progress of science with a clearness and a force which can be obtained in no other way. And at the same time one has his appreciations of the newer conveniences and luxuries vastly deepened.

So pause from time to time as you read this article and reflect upon the marvelous complexity and achievement of the daily movie. And, by the same token, make the attempt to spread this curiosity and appreciation out into the numerous phases of applied science which touch upon your life from the electric grill in the morning to the violet ray bath at night.

The story of the development of the motion picture industry is a fascinating bit of history in financial organization and international trade competition. Why the movies move is as fascinating a morsel from the recent history of applied science and the progress of mechanics.

The present excellence of clearness, freedom from flicker, and the illusion of motion in the movie are due to the ingenious application and capitalization of certain facts primarily from the field of psychology. It will be necessary to review these interesting discoveries in order to establish a basis for an understanding of why these pictures, which are really intermittent, motionless and flat, nevertheless appear to be continuous in motion, and to possess depth.

There are three questions for us to answer regarding the motion picture. First: Why is it that the pictures seem continuous when as a matter of fact the screen is in almost total darkness sixteen times a second and in partial darkness sixteen or more additional times each second? Then the second question is: Why do we get the impression of motion from these pictures which in reality are absolutely motionless? And, third: Why do the pictures have the appearance of depth when in reality they extend only to the right and left, and up and down and do not possess any objective third dimension or depth?

It is to the eye that the motion picture makes its first appeal. And since it is through vision that the apparent motion is perceived it will be necessary for us to take up first of all some phases of the structure and function of the eye as a basis for our understanding of the movies.

## I

The human eye is a miniature camera, capable of a large variety adjustments. The eye is wonderfully responsive, and automatically so, to the slightest change in light, color, or position. But it is not without its defects and shortcomings even in so-called normal eyes. It is by the capitalization of some of these peculiarities, which almost amount to defects, that the movies are made possible.

Just behind the pupil of the eye is a small crystalline lens that automatically adjusts itself to different distances and conditions

of vision. The eye thus differs from all other cameras in being self-focusing.

No light can enter the human eye except through the lens, since the remainder of the eye forms a light-proof box. The rays of light which pass through this lens into the eye are focused upon the inner surface of the eyeball. This is covered with a layer of highly specialized nervous substance which is acted upon by changes caused by the light. This specialized layer is called the retina and corresponds to the sensitive film or plate in the ordinary camera.

In the camera the momentary exposure of light causes a chemical change on the sensitized surface of the film. But before the picture can be brought into view further chemical changes must be effected by the photographer in the processes of development and fixation.

Not so with this marvelous human camera. Although vision is essentially momentary in character, due to the continual movement of the eye itself, exposure follows exposure and chemical change follows upon chemical change. There is not time to call in the photographer to develop and fix the pictures after each exposure. Indeed, there is no need.

Nature has provided the human camera with a chemical substance sensitive to light which automatically renews itself. This material is called rhodopsin, or visual purple, from its appearance in freshly dissected eyes. This visual purple permeates the entire retinal structure and is probably the keystone to vision.

The development and fixation in the human camera takes place mainly outside the eye. This occurs principally in the brain, to which the eyes are connected by a direct nervous pathway. The retina of the eye is the outpost of the brain, but the nervous material in the retina is not affected directly by the rays of light focused upon it by the crystalline lens.

There is an interesting bit of experimental evidence which demonstrates this beyond doubt. Retinas which have been washed free from all chemicals which might permeate the network of nervous fibers have been used for experimentation. It has been found that in order to stimulate this purely nervous structure of the eye directly the light must be so strong as practically to destroy these nervous elements. And still it is a matter for common observation that we can see, that is, our retinas are stimulated by lights of weak intensity.

The only explanation is the one already suggested. The light acts first upon some photo-chemical substance which bathes the retina, and the changed chemical composition which the light waves bring about stimulates the nervous parts of the retina.

Just what this substance is remains an open question. There is some evidence to indicate that it is not the visual purple. For example, Kühne found that through continued exposure to light the visual purple in a frog's eye was completely bleached. Still the frog reacted to light and changes in light in a practically normal manner after this thorough bleaching had taken place.

The visual purple is probably the chemical medium for the adaptation of the eye to light or dark illumination. In passing from the open air into the darkened motion picture theater it takes some time for one's eyes to "get used to the dark." This is technically known as adaptation, and its chemical basis in the eye is the visual purple. This same substance may have a prominent part in the general vision, or another still undiscovered chemical substance may be the basis for vision.

At any rate, vision is primarily photo-chemical. Without the intervention of some photo-chemical material the energy which we call light has no ordinary effect upon the eye.

The light which is focused upon the retina by the lens alters the arrangement of the molecules in the photo-chemical substance. This changed chemical condition stimulates the nervous endings in the retina and these carry their impulses to the brain where they are developed (perceived) and fixed (remembered).

This photo-chemical structure in the retina of the eye is not only the keystone in ordinary vision; it is through some of its properties that the motion picture is made possible. We will now turn our attention to those properties of this substance upon which the motion picture depends.

Every material mechanism exhibits a property which physicists term *inertia*. By virtue of this property matter tends to remain in a state of uniform inactivity or uniform motion unless acted upon by some external force. One finds many illustrations of this in every-day life. Let us take an example from automobiling. If it were not for the inital inertia to be overcome there would be no need for a shift of gears from low through intermediate into high in order to get the machine under way. The initial sluggishness or inertia of the machine has to be overcome before the automobile can be propelled at its usual speed. And when once under way it will continue to move when the power is shut off; it is necessary to apply the brakes in order to bring the machine to a halt. The effects of inertia are met with both in starting and stopping an automobile.

But what has this matter of inertia to do with motion pictures? A great deal, indeed. An example or two will suffice to demonstrate the inertia which is present in the eye.

It is only to be expected that we find inertia in the organ of vision since we have found the eye to be mecano-chemical in operation. Inertia is found in the eye as in any other material mechanism.

Inital inertia—the inertia to be overcome in starting—manifests itself in the retina in what is known as the latent time. A few hundredths of a second elapse between the moment a beam of light falls upon the retina and the beginning of the resulting nervous impulse in the retina. This time is consumed in overcoming the molecular inertia of the photo-chemical stimulating medium.

In the case of the automobile the inital inertia can be overcome quickest by the highest powered car. In the case of the retinal lag—the inital inertia—the latent period also decreases with an increase in the intensity of the light.

This initial lag in the retina is difficult to demonstrate except with the aid of intricate laboratory apparatus. The retinal persistence, or what corresponds to the inertia of stopping in the automobile, however, is easily demonstrated. In a recent issue of *The Journal of Experimental Psychology* I described a new apparatus for the study of visual after-images. A rough and ready demonstration apparatus along the same lines can easily be improvised.

Stand in a dark room with the eyes about two feet from a round, gas-filled, clear glass electric bulb. Remain in the dark for about five minutes so the visual purple of the eye may become adapted to the dark. Then switch the light on for just an instant, watching the bright yellow filament closely.

What is seen after the light is switched off? Although all stimulation is removed an identical image of the red-hot filament remains for a considerable length of time and is seen as if it were projected out in space in front of the eyes. Move your eyes and you will find this image follows the movements of the eye, showing that it is not imaginary but really in the retina. This phenomenon is due to the inertia and is termed retinal persistence.

This retinal persistence is always present and the experimental procedure simply accentuated it in a manner to make it readily observable. All ordinary visual images persist for about three thousandths of a second at the full intensity of the original stimulus, even after it has ceased to act upon the eye. Intense stimulation, such as the gas-filled bulb and the movie screen give, or long continued stimulation, causes the terminal inertia to remain for a much longer time.

This identical image which remained after the stimulus was withdrawn is known as the positive after-image. After this posi-

tive after-image fades away it is followed by another which is the exact reverse in coloring and hence called the negative after-image.

If you will try the light bulb experiment again you will observe, after the positive after-image has disappeared, a line identical in form and position with the red hot filament, but opposite in coloration. This is the negative after-image. Under these conditions it is usually so dark as to be easily seen even in the already dark field of the eye. Usually this dark image is seen fringed with a narrow light greenish-yellow band. When colors are used to cause these negative after-images, they always have the complementary coloration. For example, the negative after-image of a blue square of paper is yellow, the negative after-image of a green paper is red.

Negative after-images have little to do with the movies except in colored projection. They are simply mentioned here that some adequate comprehension may be given of the great complexity of the retinal inertia as it is manifest in visual persistence. It is also largely through a study of these after-images that the nature of the photo-chemical properties of the eye was first brought under observation.

We are now near an answer to the first problem which we set up regarding the movies.

As almost universally projected at present, sixteen separate pictures are flashed on to the screen within one second. In the earlier machines, as in Edison's kinetoscope, the film was passed steadily. But with the bright illumination and large pictures now in use the picture has to be still while on the screen. Otherwise nothing but one great, big, rectangular blurr would be seen.

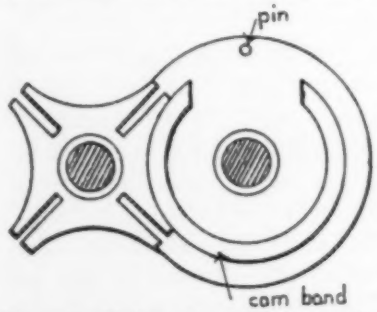



Figure 1. Maltese Cross Movement for jerking the pictures before the lens one at a time. The pin wheel revolves steadily, the cam band holding the Maltese cross firmly in position until the pin enters the slot; then the cross is turned 90 degrees. The axle that carries the cross also carries a sprocket which meshes with the openings in the film and jerks it down picture by picture as the pin pulls the cross around one-quarter of a turn.

In order to accomplish this still projection of the individual pictures to produce the motion picture each picture is jerked before the lens one at a time. A "Maltese Cross" movement, such as is used for the escapement in Swiss watches, jerks the film down picture by picture in the modern projector. That the film may be held rock steady after the intermittent "Maltese Cross" movement has pulled it down it is passed through a tension gate which holds the film tightly at all times.

The clearness, freedom from flicker and illusion of motion are all furthered by the addition of the shutter. This revolves in the path of light of the projector and is timed so that the large blade of the shutter completely cuts off the light while the intermittent movement is pulling down the next picture. The film is thus not seen while in movement but only after it has come to rest.

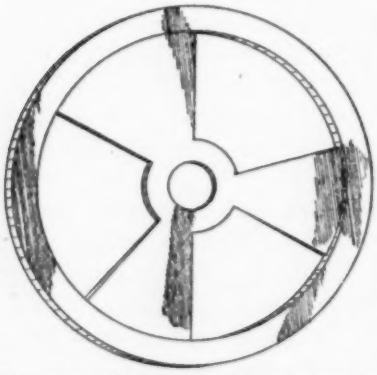


Figure 2. Shutter which revolves in front of the lens, interrupting the path of light. The large blade cuts off the light while the film is being jerked down; the smaller blades are the "flicker" blades.

This shutter cuts the light completely off from the screen while each picture is being jerked into place. Sixteen times in each second the screen is in complete darkness. In addition to this there is a "flicker" blade or two in the shutter which passes in front of the picture and partially shuts off the light while it is being projected on to the screen. The purpose of this "flicker" blade will be mentioned and explained directly.

In view of the findings of our brief survey of the properties of the eye and especially the manifestations of the retinal inertia it will now be possible for an adequate explanation to be given for the apparent continuity of the movie which is actually intermittent.

Retinal persistence is the key. Although the light thrown on the screen is interrupted thirty-two or more times each second a positive after-image of each picture remains until the next picture is projected in full intensity on the screen. The actual period of darkness on the retina is bridged over by the retinal persistence. This is what gives apparent continuity to the motion picture.

The shutter is a significant factor in giving the pictures clearness by shutting off the movement of the pictures as they are jerked into place. The absence of flicker, however, is also largely due to two other factors, namely, the intensity of illumination used and the "flicker" blade of the shutter.

The duration of the retinal lag and persistence varies according to the intensity of the stimulus, which, in this case, is the brightness of the light. As the intensity of the illumination increases, the period of lag decreases, while the period of persistence increases. Thus with the strong illumination which the modern electric arc furnishes, the appearance of continuity is furthered and the intervals of actual darkness are covered by brighter positive after-images than would otherwise be possible.

If the same films and projection apparatus that are now used to project the motion picture were combined with the old acetylene light source there would be a reappearance of the flicker due to the lengthened lag and shortened persistence. It is therefore apparent that the bright illumination not only gives clearness and brightness, but also aids in the steadiness, continuity and the elimination of the flicker.

Now to take up the part of the "flicker" blade. Upon first thought it would seem disastrous to introduce any more flicker than absolutely necessary in order to cover each jerk of the film. Obviously such is not the case. The reason for this will be made clear by reference to some laboratory experiments.

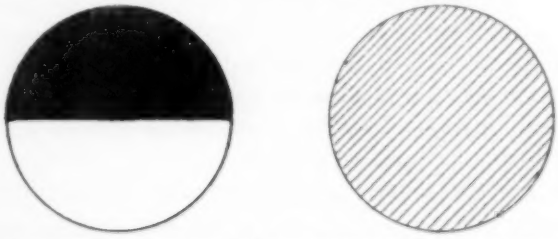


Figure 3. When a disc composed of two sectors such as is shown at the left is rotated with sufficient speed the colors fuse and produce an intermediate grey such as diagrammed. Before the proper speed of rotation is reached flicker is present rather than fusion.

When a disc composed of two equal black and white sectors is rotated by an electric motor whose speed is under control three series of phenomena are observed as the speed is increased. With only a few revolutions each second it is still possible for the two sectors to be clearly seen. As the speed is gradually increased, however, there seems to be a slight admixture of color with the black and white sectors which now appear to be pulsating slightly. These colors are known as Fechner's colors, after the pioneer in psychological investigation who first observed them. They are due to peculiarities in the photo-chemical materials in the retina.

The second phenomenon occurs when the speed of rotation is still further increased. This is known as flicker. The even, pulsating, rhythmical alternation of the black and white observed with the slower speed is replaced by an unsteady, wavering flicker which produces a great strain on the eyes. This experimental flicker is similar to the flicker which accompanied the earlier attempts to project motion pictures.

Increasing the speed of rotation still more causes this flicker to become more and more steady until at last a certain point is reached at which fusion is produced. When this is reached, the unsteady, fluctuating flicker is displaced by a blend of black and white which appears as an even, smooth, grey. In contrast to the

strain of the flicker, this fusion of the two colors is pleasing to look upon and resting to the eyes.

Stated in terms of the retinal inertia, this fusion results when the stimuli impinge upon the retina with such rapidity that the initial lag of the one blends or fuses with the residual persistence of the other.

Without the "flicker" blade on the shutter of motion-picture projector the intervals of light and darkness are so far separated that only the flicker phenomenon is produced. If the speed of the projector were increased so as to overcome this flicker it would result in each picture being shown for so short an interval that there would scarcely be time for each one to overcome the inital lag of the retina. With the addition of this "flicker" blade, however, the number of interruptions is doubled without increasing the speed and thus fusion is made to replace flicker.

It will be recalled that in the experiment just described the resulting fusion was neither white nor black but an intermediate grey. This lessening of intensity by the interruptions follows a definite course which is predictable by Talbot's law.

In modern motion picture production the overcoming of the flicker has also resulted in lessening to a considerable extent the apparent intensity of illumination in the projected pictures. But through the aid of the intense electric arc and the mirror screens the lighting used is so high powered that the resulting fusion is still bright and clear.

## II

The illusion of motion in the photo-play can not be explained in the positive way in which we accounted for the appearance of continuity and the clearness and freedom from flicker. There is still some controversy among psychologists regarding the perception of visual motion in ordinary life. The problem is gradually becoming settled, but in fairness we must review the chief accounts which are current. Then we can not only decide which one best explains the visual perception of motion in the motion picture but we can also see what the motion picture can contribute in a constructive way to these theories.

There are several of these classical theories which must be mentioned in this connection. Eye movements have been used for a long time to account for the perception of motion by the eye. This theory holds that the eye follows moving objects and that we get the impression of motion from the strain and tension on the six muscles that move each eye. There are two major objections, however, which seem to render this theory untenable in its usual form.

In the first place, the more recent experimental work indicates that after all our judgment of the movements of the eye muscles is very inaccurate. If our knowledge of these movements were used as a basis for an interpretation of motion in the external world such motions would be grossly misinterpreted to say the least. A second fatal bit of evidence against the theory is that in addition to our inaccurate knowledge of the eye movements, the movements themselves do not conform to the external motions or objects with any degree of accuracy. This is plainly shown in the illustration of the movements of an eye in following the outline of a circle.

We must look, then, to the nervous and retinal elements of the eye rather than to its musculature for an explanation of the perception of visible motion.

The phenomena of retinal streaming has been used by some psychologists as a partial explanation of the perception of motion by the eye. This starts from the fact that there is an after-image of movement. If you look at a moving stream from a bridge and then turn your attention to the bank of the stream the latter seems to be moving in a direction opposite to that of the stream. This is a negative after-image of movement and its explanation has been attempted by assuming an actual movement on the part of some of the retinal elements. But we have no corroborative evidence of this streaming of the retinal elements, in fact, what we know of the actual structure of the retina tends to contradict this assumption. It is quite improbable that the perception of motion is due to an actual and corresponding movement of certain elements in the retina.

Photograph, taken by Professor Stratton, of the movement of an eye in following the outline of a circle.

For some time it was also stated by some psychologists that there is a special sensation of motion. This was done by the earlier introspective psychologists who used the inner experience of motion, which could not be analyzed further, as the basis for their classification of the senses. The other criteria for a sensation, however, they ignored. They did not stop to analyze the physical stimulus to determine whether or not it was unique or a part of other stimuli. They also neglected to search for or indicate the sense organ which is necessary if there is to be a special sense of movement. Obviously as a special sensation movement fails to meet these requirements.

If we analyze movement as a stimulus we find that it resolves itself into a series of changes in the stimulation of the retina. Are these changes continuous and steady in ordinary vision or are they

seen only in certain progressive stages as in the motion-picture film? In other words, is the stimulation which produces the movement in the motion picture the same or different from that of daily life? We shall have an answer to this in a moment.

The eye is constantly in motion; it is never at rest for more than a few hundredths of a second at a time. Ordinarily we are completely unaware of these constant movements of the eye, but they are present and have been accurately observed and studied in detail in the laboratory. In reading a line of print, for example, the eye does not progress evenly and smoothly, but makes five or six irregular jumps.

Partial blindness characterizes the eye during these periods of their motion. For a time it was thought the eye was completely blind while in motion. It has been proved now that during these periods it is not completely anæsthetic although it senses only a vague, indefinite, hazy blurr at most.

Thus in ordinary vision, although the moving object may be progressing at a uniform rate, the actual retinal stimulation is jerky due to the incessant movement of the eye. Ordinary vision is essentially momentary in character and cross-sections motion in various phases, just as the motion-picture camera photographs progressive phases of the action. In either instance there is no difference between the perception of motion. The motion itself is not seen. What is seen is the change in positions and a blurr which may be looked upon as the sensory index of the change.

The perception of motion, both actual and pictured, is largely a matter of apperception. The movement between the positions actually seen is supplied by the mind from its storehouse of past experiences. The successive pictures shown or scenes perceived

2 1 3 4 5
out of sight they anchored their ships behind a

THIS IS AN ACTUAL RECORD OF THE EYE PAUSES IN READING A LINE OF PRINT BY A FAIRLY EFFICIENT READER. ALL OUR VISION IS CHARACTERIZED BY THESE MOMENTARY FIXATIONS OF THE EYE

serve as a framework along which the mind can fill in the idea of motion. The apparent motion results not alone from the successive stimulation in advancing position, but includes the synthesizing activity of the higher mental processes. The motion picture is no exception to real life in this respect.

And neither is the perception of motion by the eye an exception in the filling-in activities of imagery and expectation. The same filling-in activity of the mind is at work in reading. Only a very few of the letters in any line are really clearly seen, the remainder are supplied by the mind's integration. It is for this reason that the inexperienced proof-reader passes over error after

error; in ordinary perception the eye touches only the high spots, the mind does the rest to round out and complete the awareness of objects and activities.

## III

Emphasized again, we find these inner activities at work in the perception of depth, or nearness-farness, in the three dimensional objective world and in the flat two dimensional world of the photo-play.

Our ordinary environment extends not only to the right and left, and up and down, but some objects are also seen close to us while others are far away. This nearness-farness is depth or the third dimension. Just how we perceive depth was one of the first problems to receive the attention of the early experimental psychologists.

The main criteria which we have to assist us in the perception of depth take issue from the fact that our vision is normally binocular. Two eyes make us much more accurate in the perception of the third dimension than would otherwise be the case.

Two brief examples will suffice to indicate the rôle of the second eye. Close one eye and glance around your room. You will notice a loss of the plastic appearance of the furniture. It all looks flat and as if it were in one plane. Try walking around with the same eye closed and find out how inaccurate is your perception of distance.

With one eye still closed attempt to touch your index fingers together about a foot in front of your eyes. See! You missed by from one to three inches, may be more. Try doing the same task now with both eyes open. You will bring your fingers together on the first trial.

There are two prominent ways in which the fact that our vision is normally binocular contributes to our perception of depth. In the first place there is the matter of convergence. When looking at near objects the muscles on the nasal side of the eyeballs contract so that both eyes may be directed toward the objects. With far objects it is the muscles on the temporal side that contract. There is thus a measure of convergence in terms of muscle strain.

More important than convergence is the disparity of the retinal images. Since the eyes are separated by a few inches each one sees a given object at a slightly different angle from the other. You can easily demonstrate this by holding a closed book at arms length in front of you with the back of the book toward you. Look at it first with one eye and then the other. The difference between the two views is marked indeed and in each case the appearance lacks plasticity or depth.

When the same book is seen in the same position by the same eyes simultaneously a different appearance is noted. The two widely disparate views have fused into one which has depth and relief.

This principle of disparity is used in the ordinary stereoscope. The two pictures on the card are taken from a slightly different angle. When viewed through the stereoscope the prismatic lenses bend the rays of light so that the pictures are seen by each eye as if they were of a single object in front of them. Since the pictures have the requisite disparity the resulting appearance is one of a single object in clear relief.

It is not known how it is that these two images which are physiologically different still combine to form a perception that possesses the quality of depth. The important thing, however, is that such is the fact. And in this we again have an example of the integrating activities of the mind.

Motion pictures are flat and lacking in any real quality of depth or any qualities that will give convergence or disparity. Then how is it that nevertheless the observer receives the impression of depth from this representation which is in a single plane? In answering this we shall be initiated still deeper into the almost mysterious processes of integration that are accomplished by the nervous system.

At the outset it is evident that we are certain of our perception of the third dimension in the photoplay. The actors not only walk from right to left but enter and exit through a door at the rear just as they would on a real, three dimensional stage. Then we see the screen troopers gallop away and out of sight into the distant hills. There is no denying the fact that we receive the impression of depth; and there is no denying the fact that as an objective quality depth is lacking in the motion picture.

While the most accurate and predominant factors in the perception of depth are the physiological ones of disparity and convergence, there are still a large number of so-called secondary factors which assist materially in building up these perceptions. It is more fitting that these factors be termed psychological rather than secondary and of late this has come to be the common practice.

What we have long known as perspective is perhaps the most important psychological factor. Distant objects are smaller than near objects; the lines in the visual field converge toward a vanishing point. Perspective is significant in normal, binocular perception of the three dimensional world; it is ultra-significant in the flat world of the motion picture, and even painting for that matter. It is largely this factor which gives apparent depth to flat representations. Artists have long made conscious use of this in their paintings; the Japanese and Chinese still create pictures in which the

perspective is omitted. This results in a characteristic flatness and unreality in appearance.

Again in this perspective we find the integrating activities of the nervous system prominent. Although distant objects cast a smaller image on the retina than near objects the former are still interpreted, not as small people and things, but as of usual size but more remote.

Distant objects are also partially hidden by those nearer the observer. Very distant objects are also seen through a haze and are higher in the field of vision. Shadows are another factor in producing the impression of relief. Without these shadows a photograph would be flat and lack plasticity. Amateur photographers usually overlook this and their photographs are characteristically "flat" in appearance.

The motion pictures utilize all these psychological factors to give the spectators the impression of depth. In addition they take advantage of certain common illusions by having the action take place in the background rather than in the foreground; through this procedure the impression of depth is increased. Sometimes the action in the background is provided by the sea or by a breeze waving the trees. It does not need to be human action to produce the illusion.

The scenic arrangements of the photo-play are selected not alone for their artistic features but, as well, for their depth producing qualities when projected on to the screen. Although this objective screen presentation is flat and without depth, it is possible to take advantage of these psychological factors and thus produce screen dramas as full of depth and plasticity as they are of action and human interest.

Paneled walls in the screen settings are popular with the directors since these enhance the perspective of lines; round tables are discarded in favor of long rectangular ones for the same reason. The rooms used in filming the various scenes are enormously exaggerated as to depth, not primarily to produce an appearance of lavishness, but that the factor of depth may be made to stand out clearer in the projected, flat picture.

What can the scientist predict as to the future development of the technique of the photo-play? In the first place, there are hindrances to any great future development in the elimination of flicker due to the rather large individual differences in the retinal lags. It is necessary for the projection to meet the requirements of the great majority of the spectators, and there will always be some who, through physiological idiosyncrasies, do not receive the continuity of impression and clearness at its maximum. It would not be impossible for those who can afford the luxury to have their

eyes tested for the factors involved in motion picture projection and have a projector built to meet their individual requirements just the same as glasses are ground to order.

Daylight projection is not impossible but will remain a dream for many years. Certain features of the flicker phenomena are a serious handicap in achieving this end. The fusion phenomena takes place with the slowest speed and with the weakest illumination when the general illumination is at its weakest. As the general illumination is increased it becomes necessary for the speed of interruption, or the illumination of the screen, or both to be increased greatly in order to overcome flicker and retain fusion. Mechanical difficulties at present are not such as to make projection of motion with a bright illumination of the theatre out of the question.

Another handicap in the production of fusion is in the fact that apparent motion appears on the screen. This complicates the fusion and in cases of jerky or sudden motion tends to produce flicker of itself. The basis for this is demonstrated in the laboratory where simply moving the hand between the eyes and the revolving sectors which are fusing immediately brings about an occurrence of flicker. One observes this from time to time in the commercial motion picture, especially in the news reviews where football action is portrayed. The government war films of marching soldiers afford a good example of this where fusion takes place from the trunks of the soldiers up, but where flicker is seen in the same pictures where the movements of the legs complicate the projection.

Colored projection will always be hampered not only by the expense and great mechanical difficulties involved, but also by the fact that the lag varies with the colors and it is impossible to get the smoothness that is obtained with black and white. Negative afterimages of the colors which are projected with a light stronger than is usual in daily life also contribute to the difficulty of successful colored projection.

The effect of depth will always suffer so long as it is necessary for the photo-play spectators to view the pictures at distances and from angles at which they were not photographed. The maximum effect of depth is obtained when one is at the same position in relation to the scene at which it was photographed. This is one reason why extreme side seats are undesirable. And at the same time no position in the auditorium is perfect in this respect for the various scenes are photographed from different angles and distances.

The photoplay is rapidly becoming an art unto itself and is receiving the merited attention of students of art and aesthetics. Fundamentally, however, it is a triumph of applied science and is only one of the many examples of the rapid progress which has been made in this field in the more recent decades.

# THE SUB-CONSCIOUS—WHAT IS IT?

By Professor A. T. POFFENBERGER

COLUMBIA UNIVERSITY

WHEN one examines the literature concerning the subconscious he meets a mass of contradictions. It is a concept which has become popular only in recent years; yet it is perhaps three hundred years old, having been first proposed by Leibnitz about the year 1600. By those who accept it, it is considered one of the most important discoveries of the age; by those who do not accept it, it is considered nonsense. In it some find the means of curing most of the human's ills, others find the belief in it a symptom of an ailment itself requiring radical treatment. The very name subconscious seems to be self contradictory: it is a consciousness of which we are not conscious. The believer speaks of his subconscious as though it were as familiar a possession as his teeth or his hair, and yet by its very nature the subconscious can be directly known to no one—it can only be inferred. The subconscious has become so popular that one meets the term on every hand, in conversation, in the newspapers, even in the doctor's consulting room. It is quite as familiar a term as "camouflage," or "normalcy," yet it is one of the most abstruse of meta-physical or, if you prefer, of scientific conceptions.

Now the recent popularity of the concept of the subconscious rests largely upon the fact that it forms the basis for a number of theories and doctrines which are very interesting to people, such as psychoanalysis, spiritualism, mental telepathy, those wierd multiple personalities so well represented by Robert Louis Stevenson in Dr. Jekyll and Mr. Hyde, and the hysterias which are of an equally mysterious sort. There has seemed to be in the mental phenomena covered by the above mentioned terms and in others less striking in character, a real need for some concept which shall bring them all within the law of cause and effect. Without at this time attempting to give a definition of the subconscious or even of consciousness, some of these mental experiences will be reviewed, beginning with the simplest and most easily verified and passing to the more complex and less well-established ones. After this survey of material needing explanation, the subconscious will be described as it has been conceived by various authorities. I will then present an alternative view, according to which the concept of the subconscious would be made to appear superfluous.

(1). I see a play at the theater and for several days following

I think nothing about it, but on Sunday, when my mind is more at rest, I live the play experience over again. Where has the experience been in the meantime? This you will recognize as a simple illustration of memory, in which an impression is received, lost from consciousness and later recalled.

(2). I am reading a book in which I am very much interested. I follow the intricate thread of the story, and get the fine shades of meaning, and neglect entirely such mechanical matters as the letters making up the words, and even some of the words themselves, the margins of the pages, the style of the type. And yet my understanding of what is written depends upon at least some of these matters, for any changes in them will alter the meaning. How can they thus register their effect, contribute their share to the meaning of the whole, and I not see them?

(3). Wordsworth thus expressed a belief common to the normal man in the following lines:

> The eye it cannot choose but see;
> We cannot bid the ear be still;
> Our bodies feel where'er they be,
> Against or with our will.

And yet it is a well-established fact that one does pick and choose among all the objects which come within the range of his senses, those which he shall look at, listen to and feel. Without this picking and choosing life would indeed be a "blooming, buzzing confusion." Still those aspects of our surroundings which we did not choose to observe, which were neglected in favor of others, are sometimes recalled. I am very much absorbed, let us say, in reading Well's "History of the World" and am oblivious to all my surroundings. I see none of the objects around me, hear no sounds, feel no pressure of the clothes upon my body. But I suddenly recall that the clock has struck eleven. How is it possible for me to recall this experience, which I did not have?

Or perhaps I am granted an introduction to Charlie Chaplin, the king of moving-picture comedy, and, after this good fortune, I am besieged with questions about him. How did he look? Does he really wear a mustache? And his feet—are they really like that? What kind of a hat does he wear? I am much confused to discover that I can answer none of these questions. I fear my veracity may be questioned—perhaps I did not really meet him. Now it is said by Morton Prince, who has for many years been interested in such matters as this, that if I were to allow myself to be hypnotized, I could in that state answer all these questions correctly. How is it possible to give forth information while under hypnosis that I was never conscious of, that so far as I know, I have never experienced?

(4). I am listening to the roar of the distant surf, which is

made up, as every one will readily agree, of millions of tiny waves breaking upon the shore. The sound produced by any single one of these tiny waves is quite too faint to be heard. The sum of them we do hear, however. How can a million unheard stimuli produce one that is heard? A million zeros added together ought still to leave zero. The effect of each tiny wave has been described by one authority as an "imperceptible psychic occurrence." The meaning implied here is that the experience may be psychic or mental and yet not be perceptible.

(5). Let us take another case of the same sort. Suppose that you are asked to decide which is the heavier of two weights, one of them weighing 100 grams and the other weighing 102 grams. These two weights, if lifted one after the other by the right hand, will be indistinguishable to you, that is, they will seem identical in weight. Suppose then that you are given the second weight of 102 grams and a third weighing 104 grams. These two weights will also seem identical to you. But if you now compare the 100 gram weight with the 104 gram weight, you *can* tell which is the heavier. You have then this proposition: No. 1 is identical with No. 2; No. 2 is identical with No. 3. Therefore, No. 1 must be identical with No. 3. (Two things which are equal to the same thing are equal to each other.) But it is not, and you have proved it, because you can correctly distinguish between them. How shall we explain this contradiction between logic and experience?

(6). The student of mathematics meets a problem that he can not solve. He works upon it for days and even nights, but to no avail. Finally, when about to give up, he wakes some morning with the correct solution in his mind. Or perhaps the correct solution occurred to him in a dream. The following is an instance which was reported to me a few days ago: A certain member of a college faculty has been computing numerous partial correlations, a very tedious statistical operation, and has been very much interested in seeking a short-cut method of solution. A few nights ago he dreamed a method which reduces the time of computing partial correlations to one twentieth of the time required to do the same thing by the original method. Now how was this problem solved if the individual did not consciously take part in the solution? And he will testify that he did not in his waking moments.

(7). The sudden flashes of genius, the inspirations which are often responsible for great inventions, are much like the case just described. What is their source? To their owner they seem to be spontaneous, and he does not recognize them as the product of his thought.

(8). From the type of case just described, it is only a relatively short step to those that go by the name of automatic writing. One sits as if in a trance, or perhaps conversing with an associate, while

his hand writes answers to questions whispered into his ear, all unknown to him. Or perhaps as in the case of Patience Worth, a popular figure a year or two ago, the hand composes poems quite beyond the comprehension and capacity of the woman herself, and writes in languages unknown to her. To quote from a description of her case in *The Psychological Review,* "The meaning of what is written is, naturally enough, frequently not understood by her. Neither its form nor its substance is determined by her consciousness. They are apparently the creation of a self whose existence she is, for the most part, completely unaware of. And this self is no mere by-product of a more fully developed mind. Patience Worth is a personality of tremendous creative energy." Where shall we look for the explanation of these mysterious and startling occurrences?

(9). Rivers, the English psychologist, has shown that questions of a somewhat similar sort arise in connection with the study of the animal kingdom. The tadpole with all his tadpole habits—to omit the possibility of tadpole thoughts—becomes a frog with a need for an entirely different equipment of behavior. What has become of the tadpole habits in the fully developed frog? What prevents them from encroaching upon the frog habits, and playing havoc with the frog's well ordered life? Or take the frog itself, an amphibian. While living under water, where are his land habits? While on land, where are his water habits? Why do these habits not interfere with each other? How is this shifting from one set of habits to another possible without interference?

Or, to return to the human species, take the statements of Paul in his First Epistle to the *Corinthians,* Chapter XIII, "When I was a child I spake as a child, I understood as a child, I thought as a child; but when I became a man, I put away childish things."

Here is a set of problems quite like those cited for the frog. Where are the childish things put, so that there shall be no cropping up of childish speech at inopportune moments to embarrass the man?

(10). Consider now a rather mysterious case, but one which is reported in the literature as authentic. A certain man loses his affection for his wife, and matters go from bad to worse until he hates the sight of her. About this time he goes blind and remains so for years. He is permanently cured of his blindness when informed that it is a functional disturbance, the result of his wish that he might never have to see his wife again. He was barred by his religious scruples from the more customary remedy for such difficulties. How could this man have such an unfortunate wish and not know it, and how could that wish have such a terrible effect upon his bodily mechanism?

(11). There must be included in our list of cases, the so-called phenomena of mental telepathy which have been investigated by the societies for psychical research. In such cases there is reported to be a communication between minds through channels other than those of the senses. Ideas are said to come directly into the mind of the recipient. Cases have been reported and investigated in which such communication is said to have taken place over a space as great as 5,000 miles. By what means are these mental experiences to be explained? Whether they represented real cases of telepathy or not makes little difference, explanation is still necessary.

To pass from these cases to those of supposed communication between the living and the dead is not such a great step if one believes the former to occur independently of the sensory and motor mechanisms of the body. What is the solution for all these phenomena of mental telepathy and spiritualism?

---

Each of these instances which I have cited, whatever attitude one may take toward them, demonstrates a real need for explanation. How are these things possible? How shall they be interpreted? In order to help us in answering these questions, let us look to the older and more firmly established sciences to discover how they handle somewhat similar problems. Take astronomy for instance. In mapping the behavior of the planets and determining their course through the heavens, certain aspects of their behavior could not be accounted for in terms of the influences exerted by the known neighboring planets. Explanation required that there be some other influence at work. What then more natural than to conceive of this influence as being like those already known? There must be another planet, exerting gravitational force sufficient to produce the effects noted, and to exert this force the planet must be of a certain size, distance and position with relation to the other heavenly bodies. Such a planet was looked for and Neptune, at first a concept, became a fact.

In physics and chemistry there was need for explanation of certain physical phenomena. To satisfy this need the molecule was conceived, in character much like the elements already known. Later the behavior of the molecule needed explanation and this in turn led to the concept of the atom. The atom, then, is endowed with the characteristics necessary to produce those effects for which explanation is sought.

In physiology much the same procedure has been followed. In communities where certain types of food are used rather exclusively, certain diseases are prevalent. Thus the users of polished rice and corn in great quantities are subject to the disease pellagra. Communities which eat their rice unpolished and live upon mixed

diets do not have this disease. The disease is then due to lack of something in the body which is necessary for its normal functioning. This particular something, which has never been, so far as I know, directly experienced, is given the name vitamin. The vitamin is then endowed with the characteristics necessary to explain facts which are observed. Many illustrations of concepts thus formed could be taken from the various sciences. These concepts remain constructions of the mind until man can experience them with his senses, whereupon they become facts. The planet Neptune is a fact, the atom and the vitamin remain concepts.

To satisfy the need for explanation of the mental experiences which I have cited, and which do not seem adequately accounted for by reference to consciousness alone, what more natural, then, than to hypothecate another consciousness having the same general characteristics as the one we know but separate from it—a subconsciousness? The particular characteristics of this subconsciousness will be those that it needs to have in order to account for the phenomena that it was conceived to explain, just as the planet Neptune needed to have certain characteristics to produce the known effects. When experiences pass out of consciousness, they enter the sub-consciousness. The sound of each tiny wave that contributes to the roar of the surf, does not affect our consciousness, therefore its affects our sub-consciousness, and only the sum total reaches our consciousness. We do not see the margin of the page, the typographical errors, the spelling of the words in the book we are reading, but they are registered on the subconscious. If mathematical problems are not solved in our consciousness, they must be solved in our subconsciousness. We are not conscious of the wish to lose our sight—it is a subconscious wish. We do not keep track of the passage of time while asleep, but the subconscious does. Our consciousness gets its data by way of the senses, the subconscious communicates with other minds more directly. The answer to one or many of these questions, the need for explanation has been satisfied by the *concept* of the subconscious.

Since the subconscious is created to satisfy needs for explanation it is differently conceived by different authorities according to the needs that they feel. Each of the illustrative cases that I have cited gives a clue to a certain concept of the subconscious, which may be found in the literature.

There are those who look upon the subconscious as simply a repository for memories. What is no longer in consciousness has passed into the subconscious. Along with this there usually goes a very far reaching assumption, namely, that since everything passes into the subconscious, no experience is ever actually lost, but remains in the subconscious, and is capable of being recalled if the proper means be used.

This concept is expanded still further. Not only are all the accumulated experiences of the individual's life time stored here, but even those of his ancestry immediate and remote. It is said by those who hold to this view that the proper devices will also reveal these stored memories. To cite just one case taken from a book advertised as having received a prize given by the French Academy of Sciences: A young woman traced her history back through eleven previous lives, in which she was a great variety of individuals. In the ninth life, for example, she was a male guard of the Emperor Probus who ruled in the year 269 A. D. This case illustrates well the extremes to which assumptions may be carried when based on a simple but unverifiable concept.

Then again there are those who think of the subconscious as a device for recording experiences to which we are not attentive—so-called marginal experiences—as illustrated by the failure to see the margin of pages, etc. According to this view, Wordsworth is right and all objects that come within the range of our senses make their impression either in the conscious or the subconscious. It is difficult to imagine to what an extent this addition would expand the content of consciousness. Add to this also the view that the subconscious can perceive stimuli that are too faint to be perceived by consciousness, as illustrated by the perception of the sounds from the minute waves making up the surf, and you have material for making the subconscious thousands of times as populous as the conscious. There is very evident here the danger which arises from an unchecked expansion of a concept.

I will describe a third form of the subconscious in somewhat more detail, because it is the basis for the whole system of psychoanalysis with which most persons to-day have at least a reading or conversational acquaintance. The subconscious is made the repository for memories, imaginings, dreams, wishes and fears which are out of harmony with the ethical standards and ideals of the individual. There are certain contents of consciousness which must be ostracized. Since nothing can be forgotten, these unwelcome guests are driven out of consciousness, and suppressed into the subconsciousness. There is according to this view an open door between the two chambers of consciousness. Undesirable content may be removed from consciousness, but it tends to return the way that it came. There is a constant struggle to prevent the return into consciousness of what is undesirable. A censor is hypothecated who or which shall be keeper of the door and which shall admit through the door into consciousness only those contents which are desirable. But these evil ideas are not to be so easily outwitted. They try to disguise themselves by appearing in a modified or symbolic form and thus slip past the censor. Or they wait until night

when the censor is fast asleep and then slip into consciousness in the form of dreams. Or, if the censor is not then asleep he is less alert and cruder symbolism is effective in gaining a passage into consciousness. Sometimes even during full wakefulness one may find himself coveting his neighbor's wife because a malicious idea has slipped past the censor.

Now the evil contents of the subconscious have the same relation to the bodily mechanisms as do those of consciousness. Just as worry may destroy the appetite, fear may paralyze the limbs and strong expectation sharpen or dull the sensitivities, so the subconscious fears, wishes, etc., may be responsible for dire physical ills. Witness the case of blindness as the fulfillment of a wish not to see one's wife, which was cited earlier. The psychoanalyst can cure these ills. He must find the cause which is hidden in the subconscious, and appears in consciousness only in the form of dreams or cunningly disguised in the form of symbols. The psychoanalyst solves the symbols, interprets the dreams, discovers the wish, the fear and the evil thought, shows it to the patient, and a basis for the cure is then established. The treatment consists in a re-education of the patient, in developing in him a saner attitude toward his life's problems, a stronger courage to meet his fears, a sense of personal responsibility for his wishes.

Finally, the subconscious is considered by some persons to be quite like consciousness in its functions, and to be very closely related to consciousness, with the same powers of associating, creating and elaborating the material assimilated through the senses. Such a subconscious would be like the co-conscious described by Morton Prince, and represented by his cases of double personality. This basic notion of the subconscious is then enlarged to embrace functioning far transcending that of consciousness, so that the products of the subconscious activity are of supernormal character. Thus James in one of his letters written in 1901 says, "I attach the mystical or religious consciousness to the possession of an extended subliminal self, with a thin partition through which messages make irruption. We are thus made convincingly aware of the presence of a sphere of life larger and more powerful than our usual consciousness, with which the latter is nevertheless continuous." A still further extension and elaboration of this form of the subconscious frees it from all necessary connection with the physical body and allows it to float free to communicate directly with other consciousness of like sort, whether the physical body previously housing it is dead or alive. Such a view is interestingly described by F. W. H. Myers in his "Human Personality."

I have elaborated at length upon the need for explanation of a mass of experiences and the satisfaction of this need through the

concept of the subconscious. I have pictured this concept as it appears to its champions. Let us now briefly examine the subconscious in the light of the criteria which science demands that every concept shall satisfy. These criteria are:

(1). The experiences which the concept is to explain must be facts of observation.

(2). The concept shall not conflict with known facts.

(3). The concept shall resume the largest range of facts.

(4). The concept shall be the simplest possible to explain the facts.

The first of these conditions is peculiarly difficult to satisfy. When applied to our problem we find the validity of many of the experiences which I have listed certainly open to question. Some of them depend upon introspective report. They may be checked, however, if studied under experimentally controlled conditions. They do not lend themselves readily to such a check, but where it is possible, the check has often not been employed. Is it, for example, a fact that nothing is ever entirely forgotten? How shall we prove it one way or the other, and upon which side rests the burden of proof?

The application of the second criterion, that there shall be no conflict with known facts, offers some difficulty also. The objection has been raised that the one essential fact about consciousness, that needs no proof, that is self-evident, is its quality of being known, its quality of being an individual's own experience. The subconscious cannot be directly known, cannot be part of one's own experience. It therefore lacks that which makes consciousness what it is. It is self contradictory. It is a non-conscious consciousness, a contradiction of terms. To push this criticism further would lead into the realm of metaphysics. There is too little agreement about the ultimate nature of consciousness itself to derive much help from this source in the solution of our problem.

The third and fourth criteria, as to simplicity and range of facts covered can be more easily investigated. Is there an alternative concept which will be simpler and cover a wider range of facts, or are there already generally accepted concepts sufficient to account for the experiences accounted for by the subconscious? One alternative is the view that what is not conscious is physiological, that nothing need be interposed between consciousness and the functioning of the nervous mechanisms with which consciousness is correlated. Let us apply this concept to a few of our illustrations. The neural patterns or neurograms, as the traces of activity which are left in the nervous system have been called, are according to this view, sufficient to account for the facts of memory. Memories are forms of potential consciousness in the sense that when the neural patterns become active, consciousness results. The view that noth-

ing is ever forgotten or entirely lost would be untenable since these neural patterns of memory fade out with age just as the habit patterns do or as any impressions made upon organic tissue do.

Those striking conflicts between logic and psychology where stimuli too weak to arouse consciousness may by summation become conscious are easily explained in terms of the inertia of the central nervous system and the well established facts of summation of stimuli. In the case of a simple nerve reflex with its center in the spinal cord, a stimulus may be too weak to produce any muscular reaction at all, but if the same weak stimulation be frequently repeated, a full muscular response will follow. So the sound waves produced by a single tiny ocean wave may not be sufficient to overcome the inertia of that part of the nervous system concerned with hearing, but a million of them acting together may quite conceivably break through this resistance and cause the roar of the surf.

The interrelations among the neural patterns, the changing tensions within the patterns themselves, the facilitations and inhibitions that one pattern exerts upon another; these together with the conscious processes of association correlated with them are sufficient to account for much that has been attributed to the subconscious, such as the sudden solution of puzzling problems, the bursts of genius, awaking at a pre-established time, and the shiftings of habit systems and memory systems illustrated by the simple case of the tadpole and the frog. Take for instance, the supposed solution of a puzzling problem during sleep. In the examination of the problem from all sorts of angles, many sets of associative connections, wrong patterns as well as useful ones have been established. There is interference among these associative patterns—the wrong ways of dealing with the various stages as well as the right ways are fresh in the mind, and the nervous patterns of both sorts are ready to act. Let a night's sleep intervene, and certain associative connections weaken, leaving others relatively stronger. An entirely different set of relations is established among the neural patterns. When the individual awakes and his neurograms become active, the right solution corresponding to these neural readjustments, "pops into his mind."

A much simpler case may illustrate the point better. One is writing on the typewriter and makes a simple mistake, thereby forming a wrong associative connection between sight of a letter and the appropriate muscular response. He tries again and repeats the mistake—the nerve impulse takes the course of least resistance which is the recently used association path. How shall the error be corrected? A night's sleep is not in this simple case necessary, but a few moments of rest will serve to give the older, more frequently used, right connections the ascendency over the newer wrong one, and the word is correctly written. The same type of interpreta-

tion covers that multitude of cases of slips of the tongue and pen, and failures of habit mechanisms which to the psychoanalyst come under the head of the psychopathology of every-day life. Such cases of interference among association paths are known in laboratory terminology as reproductive interference. It may seem that the chances of hitting the right solution of a difficult problem in this way are very slight. Genuine cases of this sort are about as rare as you would expect them to be under these circumstances. It is their rarity that makes them so conspicuous when they do occur.

If we add to the concepts just described, the influence of motives, determining tendencies and deeply rooted springs of action, which may be thought of either in their conscious or physiological aspects, you can account for the phenomena which in the subconscious are explained by the censor and symbolism.

One is born with certain tendencies to action already established, a large share of which are commonly included in the term instinct. Some of these tendencies are, in the light of our social customs, good and some are bad. All are modified, developed and cultivated in the course of our education into forms of behavior which conform more or less closely to the demands of society. Some of these, of course, need more modification than others. These instinctive forms of behavior, as well as their modifications, are conceived in terms of neural patterns. Now when the natural sex impulses, for example, are modified by training, we need not think of both the modified and the original neural patterns as existing side by side or one beneath the other. The one has rather been modified into the other and ceases to exist. On the side of consciousness, the neural patterns are represented by determining tendencies prescribing in a positive fashion, what the individual shall do, when these neural patterns become active, rather than in a negative fashion determining what he shall not do, by the repression or inhibition of the original mechanisms. Thus in the properly trained individual the censor, with its suppressing activities exerted against what is wrong, gives way to the functioning of neural patterns and determining tendencies in the direction of what is right. The honest man is honest not because he keeps the thief in him suppressed, but because his training has developed tendencies which guide him in the path of honesty.

The phenomena of symbolism have been ably interpreted by Professor Hollingworth in his book, "The Psychology of Functional Neuroses," in terms of redintegration, or the tendency to reproduce the whole of a past experience when only a part, and sometimes a very unessential part, of the original stimulus is present. Here we have only the familiar mechanism of association in consciousness, and neural patterns or neurograms in the nervous system, with no intervening subconscious or other mechanisms.

Finally, recognize the flexibility of the imagination and the influence upon mental experience of expectation and suggestion, and you can account for the phenomena of telepathy, spiritualism and similar mysteries, if these survive at all the application of the first criterion of a concept, namely the proof of their existence as facts.

For such interpretations as I have illustrated, not a single new concept need be added to those which are already in good standing in the sciences of physiology and psychology. To the majority of psychologists this sort of interpretation, which assimilates the facts into a system of concepts already in existence, seems to satisfy more fully two of the demands of science, namely, simplicity and range of facts covered, than does the construction of a new concept. It further avoids the danger of adopting a concept which has been made to connote so much that is mystic, extravagant, and even charlatanical in character.

There is one objection which has been raised against the substitution of consciousness and brain activity for an intermediate subconscious, co-conscious or super-conscious. It is the demand that each science shall stay within its own realm. The physiologist must not introduce a psychological conception into his chain of cause and effect, nor must the psychologist fill up the gaps in his reasoning with cells and nerve currents. A conception must be in the same terms as the phenomena which it is designed to connect. The conceptions of psychology must all be constructed within the psychological series. The conceptions of physiology must be constructed within the physical series. The mathematician insists on regarding bodies as bounded by continuous surfaces, whereas the physicist is compelled to regard them as bounded by discontinuous atoms. Neither of these modes is more true than the other. The question is merely which one has the greater practical value in the particular sphere of thought in question. Add to this criterion of practical value, the two criteria previously discussed, namely, simplicity and range of facts covered, and the shifting from science to science and from physical to mental would seem to be justified.

The best established and scientifically supported concepts are not objects, but mental experiences erected upon the sum total of facts known. New facts are accumulated and concepts change. A planet was conceived to explain a set of facts and led to the discovery of Neptune. The molecule was conceived as the physical unit to explain a set of facts, but gave way to the atom; this in its turn has been replaced by the electron. What may be the fate of such concepts as the vitamin and the subconscious in the future only the future will reveal. Science performs its legitimate function today when it resumes known facts under concepts which at once are the simplest, the most inclusive and the most in accord with other known facts.

# DISEASE AND INJURY AMONG FOSSIL MEN AND THE BEGINNINGS OF SURGERY

By Professor ROY L. MOODIE
COLLEGE OF MEDICINE, UNIVERSITY OF ILLINOIS, CHICAGO

THE remains of ancient stone age man occasionally show evidences of disease and injury. These evidences among the neolithic and paleolithic races of western Europe have been studied by Raymond and LeBaron, and mention of sundry other lesions is to be found in the writings of Keith, Manouvrier, Ruffer, Baudouin and other students of anthropology. These studies are based on remains of human races found in western Europe, since no representatives of the stone age men, as they are called, have been found in the western Hemisphere. The remains of these early races are scanty, and many of the skeletal elements are normal. Some few, however, give us an insight, because of their pathological conditions, into the possible cause of their pathology and the necessity of the introduction of surgery to care for these injuries. Trephining, itself a traumatism, was introduced quite early among ancient man, as were finger amputation, cauterization and possibly scarification. These phases of primitive surgery have already been discussed in previous contributions and it remains to point out the original need for surgery, the factors underlying its development, as well as the data on which these conclusions are based.

Man's oldest representative, or man's precursor, is identified in the oldest well-authenticated skeletal manlike remains found in 1891 by Dr. E. Dubois, at that time a surgeon in the Dutch Army, stationed in Java. In the leisure of his station he had undertaken paleontological excavations along the banks of the Bengavan River, near Trinil, in the central part of the island of Java. He found, quite widely scattered, a calvarium, some teeth, a portion of a jaw and a left femur entire. These important remains were described by Dubois in a finely illustrated quarto issued at Batavia in 1894. His work was immediately received as one of the greatest contributions to the study of the antiquity of man. Although a very extensive literature has developed concerning the antiquity of man, this discovery still ranks as the most marvelous revelation of man's ancestry so far known. The interest to us in this curious ape-like form is that the femur shows

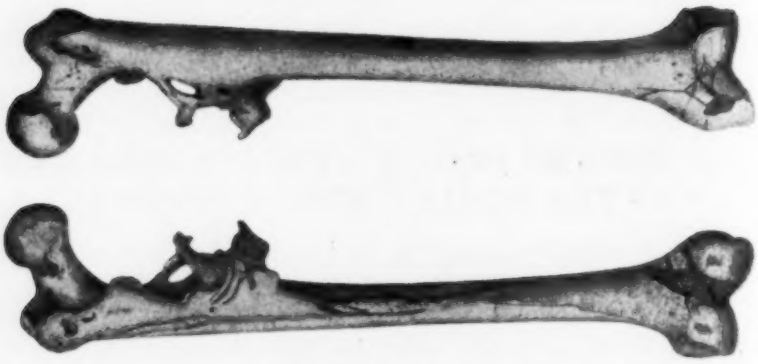


FIGURE 1

Anterior view of the left femur of the oldest known human representative, *Pithecanthropus erectus*, portions of whose skeleton, 500,000 years old, were found in 1891 in a river deposit in Java. The femur shows an extensive medial exostosis due to some chronic infection or other irritation along the line of the tendinous attachment of the iliopsoas and pectineus muscles. This is the oldest example of human pathology.

Posterior view. After Dubois.

marked exostoses (Figure 1) indicating the presence of a pathological condition of great severity. This is the oldest evidence of pathology in a humanoid form.

On account of the very great interest attached to such a discovery the pathology has been widely discussed. The great pathologist Virchow, who was also an eminent student of anthropology, called attention to the similarity of the medial exostoses on the femur of the ancient form to those seen in modern femora. He exhibited a number of these which he had selected from the collections of the Berlin Pathological Institute (Figure 2).

The next oldest known form representing man is that designated Eoanthropus, meaning the dawn man. Sir Auckland Geddes, after an examination of these Piltdown remains, decided that this ancient Englishman, who lived and died thousands of years ago, had suffered a pathological alteration of the bones of the skull. He based his conclusions on the remarkable thickness, coupled with

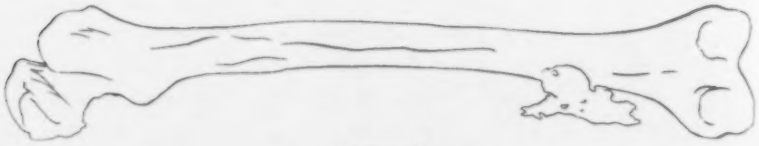


FIGURE 2

Modern human femur showing medial exostoses similar to those exhibited by the *Pithecanthropus*. These drawings were used by Virchow to demonstrate to the anthropological society of Berlin that the pathology of the most ancient man-like form was similar to modern pathology. Some scholars had argued that the femur was not human, being misled by the pathological deformation.

the characteristic outline of the temporal ridge, which can only find their diagnosis in Acromegaly. He fails, however, to differentiate this condition from Paget's disease which produces a similar pathology. It is possibly due to this factor that the remains were preserved. Thus it is seen that the oldest representatives of man had suffered from disease. Where there is a disease or injury even among wild animals, there is always some instinctive, though primitive, means of healing. While from the actual evidences nothing whatever is known of the state of surgery during the most ancient periods of man's development, may we not safely surmise that these primitive ape-like humans pondered in a vague way, over the means of curing disease and injury and thus laid a foundation for the development of that knowledge of surgery which we see emerging from the darkness in the late Paleolithic and early Neolithic races thousands of years later? An instinctive licking of an injury is the forerunner of antiseptic appliances, or the sucking of pus wounds. Quietness and seclusion after fracturing a limb was the instinctive act preceding the use of bark, skin, or hardened clay splints.

The most famous of the skeletal remains representing men of the old stone age, when surgery had its first recorded existence, are the portions of a skeleton of an extinct species of man found in a cave in the valley of the Neander River, in the Rhine province of Prussia, hence the individual is known as the Neanderthal man. The proximal end of the left ulna had evidently been fractured (Figure 3) since there is a marked widening of the articular fossa. The left humerus also shows signs of injury in consequence of which it doubtless remained much weaker than the right bone. Virchow thought that the condition of the bones of this ancient man indicated *rickets*. If so this would be the oldest evidence of rickets in man, but Schwalbe restudied the question and decided that there was no evidence of malnutrition and his conclusions are widely accepted.

FIGURE 3

**Left ulna of an ancient man, known as the *Neanderthal man*, whose skeleton, found in a cave in the valley of the Neander river of Europe, has aroused considerable interest on account of the primitive human characters which it exhibits. This skeleton, which is about 75,000 years old, shows evidences of injury in the divaricate olecranon, possibly due to a severe blow on the elbow producing a fracture. Drawn from a photograph of the original by Hrdlička.**

One of the most interesting cases of ancient injury which has come down to us is a specimen of a lumbar vertebra of a late stone age man, showing an arrowpoint deeply embedded in the visceral surface. Older injuries of a similar nature teach us that ancient man was liable to such inflictions incident to war and the chase. During this period wounds made by blows from stone hatchets, arrow and spear points are fairly common. Many of these injuries as shown on the remains found in the ancient sepultures show evidences of long standing and final healing, thus pointing, indistinctly to be sure, to some preventive measures being taken. LeBaron from his study of ancient human skeletons arrived at the conclusions that early man reduced and fixed fractures with great perfection, evidenced by the great numbers of well-healed fractures. Among 18 cases he examined only 3 had healed badly.

Nearly all types of fractures are found among the remains of ancient man. The frequency of spondylitis deformans is striking. Pott's disease was occasionally observed. Alteration of skulls due to ulcerations; scoliosis; various hyperostoses; caries of bone and teeth; atrophy of the skull; exostoses and osteomata and many varieties of arthritides indicate to us the variety of afflictions to which early man was subject. It is no wonder that, with this array of pathology to contend with, early man saw the necessity of dealing with them. While many of the earliest recorded evidences of surgery were developed as a phase of religious procedures, there must have been many therapeutic measures known to them which have not been recorded but whose presence we may infer from the pathological evidences of their skeletal remains. Surgery then in its earliest beginnings was derived from three sources: (1). Instinctive acts after injury or during the progress of a disease; (2). Surgical operations on the body which though developed in connection with religious practices often had therapeutic results; (3). Voluntary mutilations, practiced apparently since the earliest dawn of humanity. This was the condition of pathology and surgery among those man-like creatures of the hills and forest from whom the modern human races have slowly evolved.

# THE PROGRESS OF SCIENCE[1]

## GOVERNMENT CONTROL OF RADIO TELEPHONY

WASHINGTON, during the past month, has been the scene of a conference that has laid down the rules of the ether and has furnished the basis of America's youngest, fastest-growing and most astonishing industry. It was twenty-five years ago this summer that Marconi patented the first wireless apparatus in England. But the immediate events that precipitated this conference on radio telephony called by Secretary of Commerce Herbert Hoover have been only a little over a year in development. The electron tube made possible the transmission of the human voice by wireless with as much ease as over the ordinary wire telephone. During the war electrical engineers and physicists succeeded in using effectively the radio telephone between airplanes and ground stations. This accomplishment, hastened by the stress of war, has led to post-war development of the radio telephone.

On December 15, 1920, the Bureau of Markets of the Department of Agriculture and the Bureau of Standards of the Department of Commerce in cooperation took a step largely responsible for the new move-

[1] Edited by Watson Davis, Science Service.

*Copyright by Harris and Ewing*

MR. HERBERT HOOVER

Secretary of Commerce, who presided over the recent congress of radio-telegraphy at Washington, where Mr. Hoover has installed a radio receiving apparatus in his home as well as in his office

*Copyright by Harris and Ewing*

HERBERT WORK, M.D.
Postmaster General of the United States

ment. A short market and weather report in telegraphic code was sent out by radio from the Bureau of Standards as an experiment. For four months this trial service was kept in operation and the amateur radio operators on the farms near Washington were able to give their fathers information that had an economic value. They liked this prompt news, and on April 15, 1921, the air mail stations at Washington, Omaha and St. Louis took up the work of scattering the Department of Agriculture information.

From then on the story of radio rivals that of a rush to a new gold field. Manufacturers of apparatus saw the possibilities of selling outfits if they broadcasted music and entertainment, newspapers radioed news, and even the phonograph shops, little suspecting a formidable rival, advertised records by playing them into the ether. Radio became an industry. It ceased to be only a plaything for scientifically inclined boys. It came out of the laboratory into the world.

But back of this new-born industry is the radio engineer, the physicist and the electrician. The radio boom caused a cluttering of the ether. There was a demand for government regulation. The first task of science was to aid in formulating wave length allocations and the regulations that will govern future radio communication. Radio is a public utility. Broadcasting of governmental information has first rights on the ether, according to the recommendations of the conference.

In addition, the Bureau of Standards was asked to solve these problems: (1) The reduction of the rate of building up (increment) of oscillations in radiating systems. (This rapid building up of oscillations occurs in damped wave and interrupted continuous-wave transmitters, and may be eliminated by the substitution of other types of transmitter. It may, however, be reduced in these types by proper circuit arrangements.) (2) The reduction of harmonics in continuous wave transmitters and of irregularities of oscillation (''mush'' in arc transmitters and ''swinging'' of the frequency in all types of continuous wave transmitters not employing a master oscillator). (3) The comparison of the variable amplitude method with the variable frequency method of continuous wave telegraphy. (4) The preferable methods of telephone modulation to avoid changes in the frequency of oscillation. (5) The proper circuit arrangements of regenerative (including oscillating) receivers to avoid radiation of energy (as by the use of a radio-frequency amplifier with an untuned antenna or with a coil aerial). (6) The use of highly selective receiving apparatus, including a list of approved forms. (7) The use of receiving coil aerials instead of antennas, with special reference to high selectivity. (8) The reduction of interference with radio communication of other electrical processes, such as the operation of X-ray apparatus and electrical precipitation. (9) The study and standardization of wave meters.

In addition, the conference recommended that the Bureau of Standards make a study of the relation between the normal reliable range of a station and the antenna power on the basis of the use of reliable receiving apparatus, and of the width of wave band required for satisfactory radio telephony.

While the technical problems of radio telephony were being considered by a conference presided over by Secretary Hoover, engineer, Dr. Hubert Work, physician, was sworn in as postmaster general, the second scientifically trained member of President Harding's cabinet. It is said that Mr. Hoover is the first engineer to hold a high official position in the government of the United States since George Washington.

U. S. NAVY BLIMP, INFLATED WITH HELIUM GAS

Certainly there has never before been an engineer and a physician in the cabinet. Dr. Work is president of the American Medical Association. Mr. Hoover at the time of his appointment to the cabinet was president of the Federated American Engineering Societies.

Mr. Hoover has been giving the engineer an opportunity since the present administration began. Elimination of waste in industry, the unemployment conference, building and housing research, and radio regulation have all come about through his engineering. Soon after Dr. Work joined the cabinet, there was the unusual occurrence of a postmaster general presiding over a session of a conference on the public health in the United States.

## THE HELIUM AIRSHIP

DURING the same period that radio has been rapidly passing through its adolescence, the lighter-than-air phase of aerial navigation has received a series of discouragments. First came the *ZR-2* disaster in England, then the *Roma* collapsed on our own territory. These were accompanied by two administrative blows to airship building, the decision of the British to abandon airship building, and the prohibition by the Allies of dirigible construction in Germany after a Zeppelin has been built for the United States.

Within a few days after the *Roma* disaster, undaunted by misfortunes and prohibitions, commercial interests announced plans for the beginning of airship transportation in this country. Within a year a corporation hopes to have large rigid ships, built partly in Germany according to the design of Dr. Johann Schutte, in operation between New York and Chicago.

Inflammable hydrogen added to the horror and magnitude of both the *ZR-2* and the *Roma* disasters. In this unhappy way, public attention has been called to helium, the safe balloon gas. This "rare" gas, only in recent years first discovered in the sun, promises to lessen greatly the dangers of lighter-than-air transportation. All who have been concerned in the commercial development of helium hope that Congress will provide sufficient funds for the work now in progress and that the Navy blimp *C-7*, which this fall demonstrated helium to be a practical balloon gas, is only the forerunner of future American airships, held aloft by the safe gas that at present only America can produce.

THE BLIMP IN FLIGHT

## THE SCHOOL OF HYGIENE AND PUBLIC HEALTH OF THE JOHNS HOPKINS UNIVERSITY

THE Rockefeller Foundation has made a gift of $6,000,000 to the Johns Hopkins University for endowment and buildings for the school of hygiene and public health.

Since this school was opened in 1918 the foundation had furnished the funds required for its maintenance from year to year. With the acceptance of the present gift the trustees of the university assume full responsibility for the future needs of the school as they develop.

This new type of institution places emphasis upon the development of preventive medicine and upon the training of health officers. Under the direction of Dr. William H. Welch the school has made substantial progress in the four years since it was established. Twenty-seven states and ten foreign countries are now represented in the student body numbering 131. The faculty of the school comprises scientists in the fields of bacteriology and immunology, sanitary engineering, chemical hygiene, physiological hygiene, medical zoology, epidemiology, vital statistics and public health administration.

The regular courses of study lead to the degrees of doctor of public health, doctor of science in hygiene, and bachelor of science in hygiene. A certificate in public health is given to those completing certain special courses. Short courses or institutes are provided for health workers in service who can not be absent from their positions for more than a few weeks at a time. Last year thirty-six health officers from eight states took these short intensive courses.

Up to this time the school has been housed in old buildings, situated in the center of the city of Baltimore, and formerly used by Johns Hopkins University for laboratories of physics, chemistry and biology. The present gift, in addition to providing endowment, will make possible the erection of the new building for the school on a site adjacent to the Johns Hopkins Medical School and Hospital.

Work on the main building, the

plans for which already have been drawn, is expected to start this summer. It will be located on a site which has already been acquired at the southeast corner of Monument and Wolfe streets and is so designed as to admit of its liberal expansion. The contract for its erection will be let as soon as the architects, Archer & Allen, of Baltimore, have completed drawing the detailed specifications

The enterprise will be part of a general scheme of building to be started by the university this year, including in addition to the new school of hygiene, which will cost $1,000,000, $800,000 for the new Woman's Clinic and a new pathological building, the contracts for which have already been let; $500,000 for a new chemical laboratory at Homewood and between $400,000 and $500,000 for dormitories at Homewood.

## SCIENTIFIC ITEMS

We record with regret the deaths of Dr. John Casper Branner, long professor of geology and later president of Leland Stanford Junior University; of Charles William Waidner, chief of the Division of Heat and Thermometry of the Bureau of Standards; of Rear-admiral Charles Henry Davis, formerly superintendent of the Naval Observatory; of Charles Leonard Bouton, associate professor of mathematics at Harvard University; of Frank Bottomley, the English chemist, and of Senator Ciamician, professor of chemistry at Bologna.

Dr. Harlow Shapley, who was appointed director of the Harvard College Observatory last fall, has been elected to the Paine professorship of practical astronomy, which has been vacant since the death of Professor Edward C. Pickering, in 1919.

Professor Solon I. Bailey, of the Harvard College Observatory, sailed on March 1 from New York to Peru to take charge of the Harvard astronomical station at Arequipa. He is accompanied by Mrs. Bailey and by Miss Annie J. Cannon of the observatory staff.

Dr. Vernon Kellogg, zoologist, secretary of the National Research Council, Washington, D. C., and John W. Davis, attorney, of New York City, formerly ambassador to Great Britain, have been elected trustees of the Rockefeller Foundation.

Dr. George E. Hale has resigned as president of the Pacific Division of the American Association for the Advancement of Science to attend the meeting of the International Research Council in Brussels. Dr. Barton Warren Evermann, director of the Museum of the California Academy of Sciences, has been elected president to succeed Dr. Hale, and will give the address at the meeting to be held in Salt Lake City from June 22 to 24. It will be remembered that the American Association for the Advancement of Science will hold a summer meeting at Salt Lake City in conjunction with the Pacific Division.

The Rockefeller Foundation has given six million dollars to Johns Hopkins University for the endowment and buildings of the School of Hygiene and Public Health.